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GENERAL SCIENCE IS PROJECT SCIENCE.[1]

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The few words noted here are an attempt to give an idea of the rôle the science teacher is playing in this Pan-American movement to make the studies of the curriculum have a broader basis, less artificiality, and different organization. At no time, to my mind, have educators in all fields had such wonderful opportunities to thrust from the course of study the last remnants of formal, academic, falsely organized and specialized studies and allow the new learning to enter. At no time has any change in school organization, as the introduction of the junior high school, given all Americans such power to mold the character of our schools and pupils—to make them purely American.

We are all familiar with the fact that science in the school has failed to hold its position. In the report of the Commissioner of Education for 1911 we read: "Latin is holding its ground; French and German are gaining; algebra occupies a large share of time and is steady; geometry is gaining; English and history have gained materially; all the older sciences, rather strangely, are relatively falling off." Something is radically wrong with our school work in science. Where are we to find the error? When, half a century ago, there was a greater percentage of farm life and fewer up-to-date conveniences, the home and community managed to make us efficient in the use of such instruments as one might class in the domain of science. But during the last few decades advance in the field of science and invention has been so rapid that the home was not able to keep pace with it, and the school in attempting to carry the burden is meeting defeat. Indeed, man is barely keeping up with the necessities which modern life puts upon us. The man of today, whatever his vocation, is expected to know the essentials of an automobile; he ought to know something about the printing of

[1]Abstract of paper given at General Science Meeting, Teachers College.

books and where the paper comes from; how to fix his radiator when heat fails to get to it; how moving pictures are produced. And the modern housewife, to even a greater degree, must know what enables her, by means of the gas-fireless cooker, to cook the dinner, using one-fifth as much gas as formerly; why she cannot travel with her electric iron and attach it to the plug in every hotel; what ails her washtub motor on Monday morning. She must understand that aluminum ware has not all the advantages that the salesman puts forth. Not long ago very few had occasion to handle gas engines. This year alone 300,000 people have been added to the list of Ford owners and are interested in engines.

A feeling persists that science is in a category of its own. School boards are not prone to give it much weight in the course of study. The Portland Survey is typical in showing the way science is slighted. And yet, as we watch the growth of professions we find that science is in ever-increasing demand. Yale, the last institution in the country to be on the run toward scientific fields, during the last ten years increased its engineering graduates by 135 per cent, while law, medicine, education and ministry had an increase of but 22 per cent.

Today there is a tremendous demand for science by the public and the school is looked to to meet this demand. While many scoff at general science and admit it into the course of study with the idea that it is a convenient method for introducing "real serious science" which is to follow, I want to prophesy that some day, not far off, the educator will begin to realize that general science alone can meet this demand of the public. It will take its place alongside the ever-popular natural philosophy lectures of several decades ago.

The advocates of general science as summed up in Professor Woodhull's *Science Teaching by Projects* adhere to the maxim of a Spanish educator that "To educate is not to give a trade for making one's living, but to temper the soul for life." The adolescent period is just as well adapted to this tempering as any other age, and according to Professor Heck of the University of Virginia, the most fruitful period of responsiveness. The youth hungers for suggestions and can be touched as never before by the right kind of appeal. General science has enlisted to give this appeal, and instead of sacrificing anything that is to be found in so-called real science, it makes all values stand out in even bolder relief.

Poincare, in his *Value of Science* says: "Tolstoi somewhere explains why 'science for its own sake' is in his eyes an absurd conception. We cannot know *all* facts, since their number is practically infinite. It is necessary to choose; then we may let this choice depend on the pure caprice of our curiosity; would it not be better to let ourselves be guided by utility, by our practical, and above all our moral, needs; have we nothing better to do than counting the number of ladybugs on our planet?"

Probably that which factors most in retarding the improvement in science instruction is the belief that science is obscure, abstract, difficult, brain-racking, dry and valueless. These beliefs have driven people away. The indictments are legitimate when applied to a great deal of the science given in our schools today. Science is held up because of the prevailing notion that it is to get one founded in principles, fundamentals, which must be drilled in preparatory to something to come after, and that it must be given by trained specialists. When will we realize that training of this kind is detrimental, for it narrows the teacher, and that what we want are *good teachers,* not specialists? Professor Tait used to say that science aims at giving "a common-sense view of the world we live in." Huxley said: "Science is nothing but trained and organized common sense." G. S. should stand for Good Sense whenever it abbreviates General Science. Science is not a method of thinking which stands alone. The story of the mining of coal; of the construction, operation and cost of our aqueduct and delivery of water to New York; the story of the silo—all these are science. They are informational in part to be sure, but it is just that which gives them their value, satisfies the demand of the public, and enables the student to really get hold of science. General science should be informational and give facts in a general way. Why should the entire course be closely woven? Why not this lesson or a week's lesson have an organization of its own? The most educative work being carried on are the public evening lectures, Institute lectures, etc., and here organization limits itself to from one to half a dozen lectures. You might call this hodgepodge, but it is the kind of hodgepodge we need.

Science to be mastered needs to be appreciated. It must be clothed with symmetry and beauty, and this requires coördination and correlation of all the sciences. Let us forget temporarily that there are such divisions as heat, force, matter, chemistry, botany. The youth will readily read a popular magazine of

science, for instance, *Popular Mechanics,* because it does this very thing. It treats science of everyday experiences, makes it organized common sense, teaches life projects.

Lowell said: "Give us science, too, but first of all, and last of all, the science that ennobles life and makes it generous * * * Many-sidedness of culture makes our vision clearer and keener in particulars. For, after all, the noblest definition of Science is that breadth and impartiality of view which liberates the mind from specialties, and enables it to organize whatever we learn, so that it becomes real knowledge by being brought into true and helpful relation with the rest."[2]

The aim of such a course is manifold. It must first of all give a fund of information, a diffusion of knowledge from which the future scientist can choose a field, or with which the future business man, lawyer, etc., can understand the life processes which continually pop out on the surface of experience. It must enable the student to be as apt in fixing the burner on the gas stove, or in bringing forth a better garden, as he is in discussing a geometrical demonstration or Hannibal's march into Italy.

Further, the course must train in the habit of clear thinking, of investigation, and application of acquired knowledge to useful ends; in a thorough realization of the hackneyed expression that education is life, not merely a preparation for life. With Sadler we can say: "In the encouragement of the scientific temper and attitude of mind lies one of the best hopes of culture, the surest guarantee of intellectual activity and of temperate judgment in the nation, and one necessary means of preparation for the duties of citizenship."[3] But this "scientific temper" does not consist in ability to measure thousandths of a gram or to academically memorize the Periodic Table. It is the desire and ability to see all phenomena in one wholesome unity, to trace the trend of thought and view the possibilities that lie before us, to vitally concern ourselves with the solution of problems that make for the welfare of our brothers.

General science is not sugar-coated science. It endeavors to give a genuine understanding of everyday affairs, curtailing all unnecessary, highly specialized science which we are beginning to realize is solely for the pupil who will later go into pure science as a profession. It is necessary to give the youth an understanding of those things which are vital to his progress and to the progress of the race as a whole—and they are vital only

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[2]Butler, *Meaning of Education*, pp. 225-6, quoting Lowell.
[3]Sadler, in *Hodson's Broad Lines in Science Teaching*, p. XXVI.

in so far as they are appealing and concerning. President Butler says: "The first question to be asked of any course of study is, 'Does it lead to a knowledge of our contemporary civilization?' "

The most common pseudo-general-science is an eclectic course of a little from each of the sciences as they have been arbitrarily divisioned off by man. Here all uniformity is killed. Teachers simply extract small errors from large ones, and hope through recombination to give an appealing, symmetrical course. Others have tried a course in which interest is the guiding principle. Its success depends almost entirely on the personality of the teacher. If he is a Faraday who can write a book on the candle so that it will be readable, he can make his course invaluable. Today general science, while promising, has hardly begun to do its work. The texts are simply deformed reproductions of other science texts.

A general science course should solve general problems or give valuable information, involving whatever science it will. It will have a logical development, but it must be logical to the mind studying. It should deal with the real scientific environment of the youth, linking it clearly to the field of natural phenomena, introducing those aspects which are of interest and value to the student, allowing them to lead where they will, the teacher at all times keeping in mind the unity of the whole. The method should be similar to that sometimes used in teaching civics, in which several circumstances of real live material are used as the basis, and the "fundamentals," so-called, or elements, drawn in as discussion demands.

The basic error in science teaching today is that it does not center itself about the interests and desires of the student. G. Stanley Hall states this point clearly: "My purpose is solely to show the difference between the genetic or pedagogic and the logical method. The latter is essentially for the adult mind, and a great error of teachers and curricula has been that these scholastic ways of approach have been substituted for those which conform to the natural laws of growth of the intelligence, interest, and power of comprehension."[4] Today there is a tremendous demand for science by the public and our aims must be to satisfy them. If they do not, they are poor aims. The trouble is that educators put a damper on the natural desire for science by their method of treatment. Many feel that if it is not complex, it is not science,

[4]G. S. Hall, *Love and Study of Nature,* Mass. State Board of Agric., 1898.

and do not see it as useful information. Teachers think that science must be difficult, and whenever a choice offers, choose the more inexplicable thing. President Butler says: "It is a common thing to hear it said that since life is full of obstacles and character is strengthened by overcoming them, so the school and college should not hesitate to compel students to do distasteful and difficult things, simply because they are distasteful and difficult. I do not hesitate to say that I believe that doctrine to be profoundly immoral and its consequences calamitous. But, it is answered, you certainly would not trust to a student's whims and allow him to do or not do as he pleases. Certainly not—that is not the alternative. The proper and scientific course is to search for the pupil's empirical and natural interests, and to build upon them. This requires knowledge, patience and skill."[5]

Teachers feel that no statement should be made that is not complete, forgetting that the meaning of "complete" varies with the age of the pupil; and in order to accomplish this completeness and gather up all stray ends, they feel that it is absolutely necessary to use formulæ and definitions, which seldom mean anything to the pupil. It has been claimed that general science by the project method is superficial. I am not so sure that even if it were superficial it would be worse than being artificial as science teaching now is with this host of definitions and formulæ. The besetting sin of the teacher is the idea that nothing in science is educational unless it is thorough. This does not hold true in history. Why should it in science?

The subject taught, whatever it be, must be attended by a purpose or motive on the part of the student. Where this is lacking, the project supplies it. Where it is present, the project meets it to the student's satisfaction, leading him to further problems. We who have passed the high school age do not go to our chemistry text to understand the qualities of the tires on our car. Nor do we go to the technical discussion of the storage battery in our physics text to enable us to fix our battery. We read literature from the automobile company because it satisfies. It is vital, concerning, appealing, touching closely to the project we have at hand. Children are men and women immature, and do not enjoy or profit by studying the dry, unrelated, to them artificially organized, facts, principles and theories set before them any more than we would. When we want to begin keeping hens, or if we want to make good butter, we get a *Farmer's*

[5]Butler, *Meaning of Education*, p. 85.

Bulletin. This cracks the nut. Projects for general science should do the same thing. General science should not be crystallized between two covers of a book, but should consist in a variety of projects, one suggesting the next for a while so as to give a unity to the child's mind during this period. Only in this way can we hope to give a science that will attract and satisfy the child and the public, and give something that will be lasting and useful in later life.

THE USE AND ABUSE OF THE LIBRARY IN THE TEACHING OF PHYSICS.[1]

BY THOS. E. DOUBT,
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In the consideration of the use and abuse of the library in the teaching of physics, the welfare of the child must be our foremost thought. No two children are exactly alike, yet all have common requirements in mental discipline, in opportunity for growth, and in intellectual assimilation. The sterling traits of individuality are worth all it costs to preserve them.

Good teachers would not have much difficulty in imparting instruction in physics without books. In fact, this would be an ideal way if economy of time and teaching effort were no object. The ancient Greeks were masters of this method of teaching, and used it effectively in giving instruction in philosophy. The positive dislike of Greek thinkers for detailed experimental inquiry delayed the progress of science two thousand years. For instance, instead of acquiring facts about optics they spent their energies in speculating about the nature of light.

To secure the best results for the normal child with this method, the requirements are the ideal teacher and unlimited time. In intermediate and secondary schools, individual instruction is altogether too limited. Time is wasted on nonessentials. Students are rarely encouraged to follow up their own initiative.

The textbook must be available whenever the teacher cannot be appealed to and for guidance, the library must furnish most of the attractive signboards and projected illumination on the roads which the student seeks to travel.

Though physics originated less than four hundred years ago,

[1]Read at the spring, 1915, conference of the affiliated school with the University of Chicago.

much biographical material is available and would be attractive to any student who enjoys reading good books. Biographies of living men are more attractive than those of earlier times. This furnishes a rich field for the current magazine which the wide-awake librarian will not be slow to preëmpt. New discoveries are always alluring and legitimate subjects for wide reading.

Perhaps with adequate guidance, we would occasionally have boys like James Clerk Maxwell who was experimenting on elastic solids at the age of eleven and at fifteen, he was reading that prose poem of mathematical physics, Fourier's *Analytical Theory of Heat.*

Certainly it would not lessen the interest of girls in physics to read incidents in the lives of Caroline Herschell, Madam Curie, or of the late Mrs. Professor Draper. For boys contemplating the engineering profession, the story of what Rowland did at Niagara Falls; what Kelvin did for the Atlantic cable or what Eads did for the Mississippi river would be interesting reading. Not less interesting would be the sketch of what our two noble Americans did at Panama, the achievements of one in medicine and the other in engineering having been recently recognized by Congress.

Prof. Millikan told me that his son, only eleven years old, has read the book *How It Works* through with absorbing interest and is a constant reader of the *Technical World.* All children are interested in the "go of machines"; why not supply them with books that would stimulate this interest?

This spirit of wonder which a child has, assuredly should not be dampened as the child grows older, but should be intensified and deepened with maturity. Great men frequently show this spirit of wonder in striking form and it is a privilege for young people to be associated with them. The library furnishes the means for bringing this companionship even to the humblest child.

Lord Lister, the famous antiseptic surgeon, manifested this receptivity to a remarkable degree. His senses were highly developed and they all seemed to be keenly alive to every impression. With his brother, the curator of the British Museum, and Sir Michael Foster, he was walking across a western college campus one summer day. The grasshoppers were thick and flying frequently with a clattering noise. Lord Lister was immediately attracted by the noise which to him was new. All his senses were aroused. The novelty of the phenomena attracted him and he

sought by question and observation to become more thoroughly acquainted with those insects.

Another illustration might be cited. In the great library of Prince Louis Napoleon, where ponderous volumes were ranged shelf upon shelf—such works as were created by Humboldt and Bonplandt after their return from South America—a conversatione was being held in honor of the Congress of Physicists in Paris in 1900. The exhibits were such things as X-rays, wireless telegraphy, liquid air, multiple telegraphy, Tesla coils, all new at that time. Among the many distinguished guests were Lord and Lady Kelvin. Lord Kelvin showed this same spirit of wonder, heightened curiosity, all senses alert for every possible sensation. It was impressed upon me then and the conviction has grown with observation and reflection since that great men are direct in their actions. Their greatness is made up of simple elements greatly intensified. They bring to their help not only well-trained senses but eyes gained by knowledge. This attitude of mind is characteristic of unspoiled children. Alas, how seldom we meet with it in secondary schools. The library has no small function to play in fostering and keeping alive this natural prerogative of child life.

But, how frequently have we observed the spirit of inquiry killed in a bright student when he is sent to an encyclopædia to look up a certain subject. The article in question is usually written by an expert for experts. One illustration would show the folly of such a use of the library. In the old Encyclopædia Britannica, there is an article on "Wave Theory" by Lord Rayleigh. It was used by a university professor as the basis of a course of lectures four times a week for three half years to graduate students. The last edition of the Encyclopædia Britannica has this article split up into a number of sections and distributed throughout that great work; nevertheless the principal paragraphs are as difficult reading as in the preceding edition.

However, we must admit that a man should have a wide use of reference texts and encyclopædias. To learn an effective use of these resources, the student must have guidance that is readily accessible. Not only should a good card catalogue be available but bibliographies with some estimate or appraisal of the different articles should be accessible on important topics.

At the Armour Institute of Technology, I am giving a course in "Radiation" as an elective to about a dozen advanced students. Our librarian worked up the bibliography of the subject and the

result was forty typewritten pages of titles and this included only magazine articles within the last four years. If carefully classified and evaluated this should prove of good service to the student.

The reading room of a library should be a place where any child would be delighted to go, not only for a few minutes but regularly. An extension of the library may readily be made by the use of the opaque projector. The page of any book may be shown to a large audience. Thus the large cabinets of lantern slides no longer need to be indefinitely expanded.

The use of numerous texts for collateral reading is not an efficient plan. No two texts are written with the same idea in mind, so that the student is discouraged and his energies dissipated in attempting to get the new author's viewpoint. There is exhilaration to the student in having definite requirements in the text for each day after the instructor has given an introduction. The student gathers momentum as he progresses if he is held for these definite assignments.

Encyclopædias, reference works, and collateral texts are of great use to the teacher and large expenditures may be justified by the librarian for such books on the ground of secondary effect upon the students through the instructor.

Clerk Maxwell has been mentioned. He is worthy of all honor and confidence. His treatise on "Electricity and Magnetism" has been the point of departure for most of the researches on the subject for the last forty years. He wrote a little book, *Matter and Motion*. It is a classic, a model of its kind and has been recommended to high school teachers for the use of their pupils. What is difficult reading for the average college student certainly cannot be easy reading for students of less maturity.

Newton's *Principia* would not be a good book to put into the hands of a high school pupil if we would have him learn how pressure produces motion nor would we give him Maxwell's *Treatise on Electricity and Magnetism* to be used as a text, admirable as these works are, but we should encourage the spirit of play such as Newton exhibited in his study of soap bubbles or a better instance, because more modern, the way in which Faraday played with wires and needles in his researches in electricity and magnetism.

A number of years since, I gave a college course in physics without the use of a textbook. My students were supplied with mimeographed notes of the important statements in each lecture

and referred to the library for the bulk of the subject matter usually given in a text. We began with the subject of heat and developed the principles of mechanics as the need arose for them in dealing with thermal phenomena in much the same logical order that Maxwell followed in his initial course in experimental physics at Cambridge University. The course was largely illustrated with experiments in the lecture room and supplemented by a closely correlated course of experiments in the laboratory.

I followed this plan for two years. The students seemed to have developed the scientific attitude more readily and while not depending upon memory so much, their thinking was more precise and dependable than the students who used the textbook the three previous years. High school students are not usually prepared nor have they the ability to take good notes of lectures. Even college students usually have difficulty in mastering a subject given only in lectures. Hence a textbook properly interpreted by the teacher supplies the omissions in the lecture and even corrects the mistakes of the teacher himself.

Is not one of the aims of a course in physics not so much to develop the habit of reading as to encourage the use of the ability to think? It is true as Maxwell points out that we should imbue the minds of our students with correct dynamical principles and "provide for the diffusion and cultivation not only of true scientific principles but of a spirit of sound criticism founded on an examination of the evidence on which statements apparently scientific depend."

Helmholtz made considerable progress in pure mathematics after he had accomplished his monumental work in sound. A student will make much more rapid progress in the study of physical principles by means of books after he has a firm foundation in sense perceptions from a good course in laboratory work. Deductive physics may be good for advanced work in college but it does not commend itself to me for use in secondary schools.

Those who are studying radioactivity tell us that there are sources of energy locked up in atomic structures which are almost limitless and so far we have been able to appropriate these stores only to a very slight extent. Anything that we can do does not seem capable of accelerating or retarding the rate of evolution of this primordial energy. The analogy to the educational problem is obvious. We subject the pupil to observation, to various conditions more or less favorable to his development in the hope that we may discover an environment which will unlock the soul

of the child and set free his boundless possibilities. We seek to teach by practical methods the elements of letters and of science and the art of accurate expression, the ability to think and to control the will. And undoubtedly we can believe with Michael Faraday that that point in self-education which consists in teaching the mind to resist its desires and inclinations until they are proved to be right, is the most important of all, not only in things of natural philosophy but in every other department of daily life.

Physics is an experimental science. There are real and great difficulties in the subject itself to every earnest student. Speculation has a very subordinate part without we use detailed experimental enquiry for the acquiring of facts and the testing of hypotheses. Too often the child is encouraged to spend his energies in speculating like the ancient Greeks about the nature of phenomena instead of giving real descriptions of the facts. The test and proof of our efficiency is found in reviewing, in rethinking, in reknowing, and in reproduction of the subject matter in language at once appropriate and precise.

Professor Fitzgerald of the University of Dublin once wrote that the cultivation and training of the practical ability to do things and to learn from observation, experiment, and measurement is a part of the education which the clergyman and the lawyer can maybe neglect because they have to deal with emotions and words but which the doctor and the engineer can only neglect at their own peril and that of those who employ them. Sir John Morley says the essential thing for progress is to leave all ways open for the advent of your hero, for no man can possibly know by which road he will come; and this is as true in science as it is in the affairs of government.

The total production of all kinds of steel ingots and castings in 1913, according to the American Iron and Steel Institute, whose figures are accepted by the United States Geological Survey, was 31,300,874 long tons, against 21,599,931 long tons in 1912. The production of steel by the electric process in 1913 amounted to 30,180 tons, compared with 18,309 tons in 1912. In 1908 only 55 tons of electric steel was produced. On December 31, 1913, the number of completed plants which were equipped for the manufacture of steel by the electric process was nineteen, an increase of five over the number a year previous.

DIAGRAMS FOR SOLVING PHYSICS PROBLEMS.

By John W. Scoville,
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By means of diagrams it is possible to solve hard problems in specific heat and heat of fusion in about thirty seconds. These diagrams are useful in checking up the measurements of students in calorimetry experiments; in a few seconds the teacher can tell the student whether the observations are accurate enough to warrant him in going through with the calculations or whether he should repeat the experiment in order to get a new set of data.

To make a diagram for solving problems in specific heat, draw a horizontal line, about forty-five centimeters long, and divide it into one hundred units. This is the temperature line which is shown in Figure 1. Above this line and parallel to it, draw lines

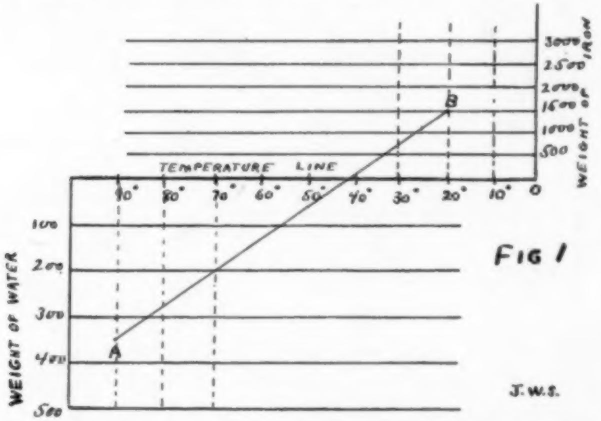

FIG 1

to represent the weight of metal taken and similarly below the temperature line draw lines to represent the weight of water into which the metal is dropped. The spaces between the upper parallel lines will be less than the spaces between the lower parallel lines; the ratio of the width of the upper and lower spaces being the same as the ratio of the specific heat of the metal used to the specific heat of the liquid into which it is dropped.

Suppose the diagram is constructed and we wish to solve this problem: 1,500 grams of iron at a temperature of 90°C. is dropped into 350 gms. of water at a temperature of 20°C.; what will be the temperature of the mixture? Insert a pin in the diagram at A to show the weight of the water and the temperature

of the iron. Insert another pin at B to indicate the weight of the iron and the temperature of the water. Place a straight edge against these pins and where this crosses the temperature line, read off the temperature of the mixture.

Figure 2 shows a diagram for solving problems which deal with the mixing of ice and water. The temperature line is 180 units long and the spaces above and below it are of equal width. Suppose we are to solve this problem: 200 gms. of ice at temperature of zero is dropped into 400 gms. of water at temperature of 80°C.; what will be the temperature of the mixture when the ice is melted? Insert a pin A on the vertical line at the ex-

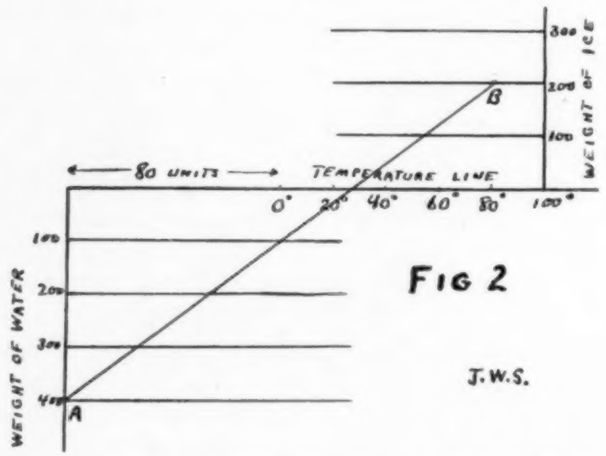

FIG 2

treme left of the diagram to represent the weight of warm water. Insert a pin B to represent the weight of the ice and the temperature of the hot water. Place a straight edge against these pins and where this cuts the temperature line, read off the temperature of the mixture.

Suppose we were to find out how much ice would be required to cool 400 gms. of water from 100°C. to 0°C. Insert pin A as shown in Figure 1; put the second pin on the temperature line at 0°, connect the two with a straight edge, and where this cuts the vertical line at the right of the diagram, read off the weight of ice required.

A diagram like Figure 2 can be constructed to solve problems in the condensation of steam. The distance marked 80 units in Figure 2 will now be made 536 units long, the whole temperature line being 636 units long and the zero reading being at the extreme right.

Figure 3 shows a diagram for solving problems on lenses or joint resistance. Draw BD perpendicular to EC and draw AD to bisect angle BDE. On BD, DC, and ED mark off equal spaces. At these points on ED erect perpendiculars to cut AD. The spaces on AD will be longer than the spaces on DC or DB. Suppose we wish to find the image distance when the object distance is 4 and the focal length of the lens is 1.5. Insert a pin at A to indicate the object distance, insert a pin at B to indicate the focal length of the lens. Place a straight edge against these pins and where this cuts the line DC, read off the distance of the image from the lens. It can be seen that if the object

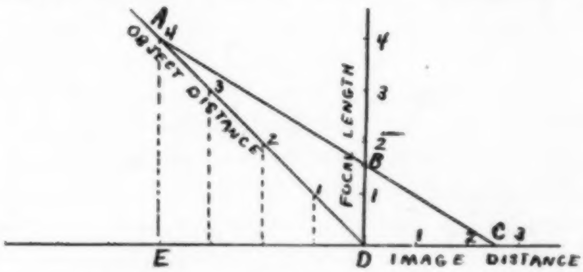

FIG 3

distance is infinite, the image distance is the same as the focal length. If the object distance taken is less than the focal length, the straight edge will intersect the horizontal line at the left of D, indicating that the image is now virtual.

To use this diagram to get joint resistance, insert a pin on DC to indicate one resistance, insert a pin on AD to represent the other resistance, and where the straight edge connecting these pins cuts the vertical line, read off the joint resistance of the two wires in parallel. Transferring this resistance to the line AD, it could be combined with the resistance of a third wire, and so on.

Describe construction of Leclanche cell.

A.: Packed around the carbon is magneise of dioxide and emersed in sulphuratic acid.

Q.: Why is a balloon not completely filled before releasing?

A.: It would rise too quick and the outside air gets in as it goes up and the higher up it gets it condenses because the air is hot high up.

State how the freezing point is marked on a thermometer.

A.: Place it in melting ice and mark how high the rerchery goes.

ALMOST APPARATUS.

By H. W. Farwell,
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I don't think that I have ever recovered from a disappointment which I suffered in my boyhood. The advertisement of a telescope, which I had seen in some more or less reliable journal, was the cause of the trouble. The description was so suggestive and the accompanying picture so attractive that I felt that if only it were possible for me to possess such a beautiful instrument, the world would be mine forever. At last my grandfather sent for this unusually valuable scientific article, and when the package arrived he presented it to me with due ceremony.

To my first glance that telescope looked just like the picture, but soon I began to discover some differences. The first thing I noticed was a flaw in the brass cap at the small end, then the sliding tubes were only too evidently constructed from brown paper, and finally I found that after very careful focussing, by holding the eye in a very definite position, and by keeping the telescope very steady, I could see the trees across the fields almost as clearly as I could without the coveted instrument.

With such is science too frequently aided (?). The evil done in this way in many secondary schools and small colleges is probably greater than that wrought by the over-expensive unnecessary apparatus of a few institutions where ideas of experimental physics are illustrated by impressive nickelled and lacquered whatnots in dustproof cases. But this is another story. The work with the hopelessly inadequate and flimsily constructed appliances is generally worse than none at all.

There always will be, I hope, boys with a type of constructive ability sufficient to solve experimental difficulties with the crudest sort of apparatus. They are, however, so few in number that they may be omitted from consideration here, and anyway it is hardly right to handicap these few by over-emphasizing the wrong thing. Neither would one wish to present experiments in which there were no difficulties. Such would afford no opportunity for developing the mind of the student along some very desirable lines, and would, after all, give no true conception of the reality.

The purpose of laboratory instruction is primarily to give the student first-hand knowledge and acquaintance with phenomena, the qualitative view, and then to enable him to determine the magnitude or quantitative value of what he has seen. Acquain-

tance without measurement is often misleading, and tends to superficiality, already too prominent in circles wider than those drawn about educational institutions. The student should expect to see what he is looking for, not merely to get a glimpse, but to identify in some manner such as measurement affords. Not until he has done this can he truly say that he has cónducted an experiment. If the performance can not be repeated with practically the same result, naturally he gets little or no benefit from the laboratory.

The conclusion is then that no apparatus should be put into the hands of elementary students unless it will meet these requirements of laboratory instruction. Such a test would doubtless put a great deal of well-advertised so-called apparatus on the back shelves, where it belongs. However, a further criterion is necessary, and this of a most practical nature. Teachers who handle large classes find it continually advisable to caution students to use great care in handling even some of the most simple pieces, and with all this expect each year no inconsiderable crop of breakages. There is a point beyond which cheapness is no longer a virtue. Apparatus which will not stand up with real use is dear at any price. A laboratory should give the students every opportunity for handling instruments and observing their construction and operation. If it is necessary to curtail this opportunity in order to prolong the life of the apparatus, the instruction is faulty.

It may emphasize the point if I cite a few definite cases. Take, for example, the very common and invaluable thirty centimeter ruler. An examination of a number of rulers showed several with errors as large as five millimeters in the whole length, and edges which were very far from giving the shortest distance between the end points. A millimeter division in one part of the scale might be nearly twice as long as one at another point. Yet we claim that the measurement of length is one of the most accurate possible, and frequently call for measurements to tenths of a millimeter!

Spring balances come in for no little criticism, as the weighing of the same object on several of the cheaper balances will testify. Yet it is possible to obtain satisfactory balances at a reasonable price. Galvanometers seem to have received from the manufacturers of elementary apparatus a great deal of attention of a doubtful character. It is now possible, I am told, to purchase one of the moving coil type, new, for less than $2.00. To a

school board or purchasing agent all galvanometers may look alike, but the man who uses them will distinguish between galvanometers and "junk."

The equipment for experiments with mirrors and lenses is in many places a source of more annoyance than profit. One teacher recently stated that students could get quite good results with a few blocks on a table, and wax with which to fasten lenses and screens to the blocks. A meter stick made the outfit complete. Simple as it is, this is far better than much of the more elaborate devices I have seen. However, I can hardly agree that this is all that is desirable or even necessary. Good apparatus commands respect, and never have I seen a better illustration than in the case I mention below.

A few years ago our equipment for optical benches was rapidly becoming useless, through breakage, repeated bending, and various ill-advised attempts to use pieces as the maker never expected that they would be used. There was no suitable apparatus on the market at a price which we could pay, so with the aid of our mechanic and the co-operation of a colleague I built a bench with fittings which seemed to meet all our requirements. There was nothing new or startling about the outfit, it was not expensive, and it would stand any amount of use. The first class had not finished their experiments with the bench before students began to ask where they could purchase such an outfit for use at home. We were fairly compelled to go to an apparatus firm and ask them to manufacture this equipment. Since then there has not been a class in which some men did not purchase benches on which they could continue experiments at their leisure.

I hold no brief for the apparatus firm. I have already spent more time in persuading them to make the bench than they would be willing to pay for. But my point is that the students recognized that the outfit was worth while. And so it is with the other experimental work. The equipment for which apology is necessary, which demands unceasing attention to avoid errors in manipulation, will always hold the mind of the student on the wrong thing, and in the end serves only to permit the statement that the student has spent so many hours in the laboratory, and has performed so many "experiments."

Where the fault lies I do not know. Manufacturers will probably never refuse to make stuff which looks as well as apparatus in a catalogue, so long as individuals will spend money for it;

teachers will probably always attempt to equip their laboratories with the appropriations set aside for that purpose; school authorities will probably be as generous as the taxpayers will permit; and few people wish to increase the tax rate. Yet somewhere along the line there should be men and women of force and determination who will not allow the further existence of "almost apparatus."

Q.: How can the acoustics of a hall be improved?
A.: By having a slightly doomed ceiling.

Q.: How do the air particles move during the passage of sound?
A.: The air particles move back "and forth."

THE TESTING OF RUBBER GOODS.

The Bureau of Standards, Department of Commerce, is about to issue the third edition of a circular on the testing of rubber goods. This publication which has been very much enlarged is fully illustrated and describes in detail the method of procedure in conducting physical and chemical tests of rubber. The testing machines and apparatus developed at the Bureau of Standards greatly facilitate the testing of rubber and the object of this circular is to assist manufacturers and consumers in establishing standard specifications and standard methods of test. The subject matter proper is introduced by a brief outline of the processes through which rubber passes before reaching the factory, followed by a short description of the usual processes of manufacture, which include washing, drying, compounding, "making up" various articles, and vulcanizing. The physical tests most commonly employed are explained very thoroughly. These include tests for tensile strength, ultimate elongation and elasticity. Conditions affecting the results of tests are discussed at some length and experimental data are given to show the necessity of a standard procedure in testing.

A general discussion of the chemistry of rubber is followed by a brief explanation of the object of each of the analytical determinations that are commonly made. After this there are given in detail the methods in use at the Bureau for each of these determinations. They are not entirely original, but have been compiled from the various publications on rubber analysis, from the information gained through the routine testing of rubber goods for delivery on Government contracts, and from co-operative research with various scientific organizations.

The tentative method of analysis and specifications for thirty per cent Hevea insulation compounds, adopted by the joint Rubber Insulation Committee, are next given:

A bibliography listing the more important books and journals devoted to rubber, and the Bureau's regulations regarding the testing of rubber goods conclude the circular.

Copies of the publication, *Circular No. 38,* may be obtained by interested parties upon application to the Bureau of Standards, Washington, D. C.

THE DISTRIBUTION OF WEEDS BY MEANS OF FARM SEEDS.

By Katharine Thompson,
Normal School, Macomb, Illinois.

A weed is a plant which grows where it is not wanted by man. All foreign seeds in any variety of farm seeds may, in this sense, be regarded as weeds; but in our thought of them they immediately fall into two classes. First, the seeds of other farm plants, valuable in themselves, perhaps, or at any rate not harmful, but not desired along with this particular crop. Second, the seeds of plants not wanted on the farm under any condition—those plants which, from some characteristic or other, have become pests. These plants lower the value of the crop by absorbing from the soil the moisture and food needed by the crop, by smothering or strangling it through their rank growth, or by stealing from it its life juices, as does the parasitic dodder; they lower the value of the land upon which they grow, because it is a tremendous task to eradicate them from a field once they are established there. This is the type of weed which is to be considered in this report.

Besides reducing the value of the crop and decreasing the value of the land on which they grow, weeds increase the expense of harvesting a crop; e. g., grain badly entangled with bindweed entails trouble in cutting, handling and threshing, and, unless cleaned before marketing, has, in the states where seed laws are in effect, a greatly reduced market value. Some species of weeds are poisonous to cattle, as Jimson weed, pokeroot, wild black cherry, or ergotized seeds of any of the grasses; they may be poisonous to man, as, it is said that the flour ground from cockle-infested wheat has been known to cause violent illness. The flavor of the meat or the milk is sure to be affected when cattle eat pennycress, wild onion, etc. The state of Iowa was estimated to have lost twenty-five million dollars through weeds in 1912.

These and other ill effects brought about by allowing weeds and weed seeds to grow and flourish render it very desirable to rid ourselves of them as far as possible. With this purpose in view, the U. S. Department of Agriculture and many of the state governments through their Experiment Stations have been working during a number of years on the problem of the control and extermination of weeds. The first step toward the solution

of any problem is to understand and state its conditions, and this is what these various agencies all over the country have been trying to do. They are discovering by the analysis of thousands of grain and grass samples what the impurities in the seeds are, who or what is responsible for their being there, and what are the best steps to take to get rid of them.

The educational part of the work has been and still is, very important. Its aim is to reach by literature, lectures, etc., the mass of the farmers who are sowing the seed, to lead them to see the importance, the absolute necessity of using clean seed, and of keeping fields, pastures, roads and waste places, free from all sorts of weeds; to teach them which are the bad weeds and what should be done to kill them; and to train them to make use of the scientific equipment and the scientists provided by the state and national governments to help them make their work more effective.

The next step is to secure laws which protect the farmer by forbidding the sale of impure seed, and to have these laws enforced. Reports from many of the states indicate good co-operation from the dealers in trying to enforce the laws and raise the standard of their seeds. But even though the dealer may be very careful to have his seed as pure as possible, it is likely to contain some weed seed, as the seeds of certain weeds resemble the grass seeds so closely in size and weight that it is very difficult to separate them. On the other hand, some dealers, according to the data from certain states and from the samples secured from foreign countries, either adulterate their seeds or are very careless about what gets into even what is sold for their best grades of seed. This is especially true in those seasons when there is a short crop of the seed most in demand. The Department of Agriculture recommends that seed containing more than one per cent of foreign seeds be considered below grade. This would mean of course less than one per cent of weed seed. By reference to some of the following tables it will be seen that the number of weed seeds present in one per cent of the weight of the seed might easily be very large.

A great many weed seeds are spread by the commercial stock foods on the market. They are mixed carelessly, often from low-grade grains or the screenings of better grades, and contain large numbers of weed seeds. The juices of the alimentary tract have no effect upon these hard seeds, and they are deposited on the land, carefully spread out in the barn-yard manure, to

get an excellent start, perhaps even to seed, before the farmer realizes that they have settled down on his premises.

Other seeds are spread by adhering to the sacks in which grain or grass seed has been carried, and still others travel from farm to farm in wagons, sleighs, threshing machines, fanning mills, baling presses and other farm machinery. Perhaps the most curious carriers reported are vegetables such as potatoes and carrots which are penetrated by the spiny parts of quack grass or Bermuda grass, thus holding the seed so that it is ready to grow when the vegetable is placed in the ground to mature.

But, according to the records of the Department and the various other sources of information, it appears that the most prolific sources of distribution for weed seeds on the farm are farm seeds, especially commercial seeds and those sold as food for farm animals. The greater part of our most aggressive and unmanageable weeds are not of native origin, but have been introduced in seeds or imported grains, and, having found the new environment more favorable than the old, have spread and flourished throughout the greater part of the country. Many examples of such weeds might be given, among them being the Russian thistle, orange hawkweed, pennycress, dodder, quack grass, several species of mustard, and the widely spread buckhorn or rib grass.

The tables, lists, etc., which follow have been selected from data furnished by the Experiment Stations of Iowa, Kansas, North Dakota, Michigan, Kentucky, Maryland and from a thesis from the University of Wisconsin. The heading explains each of them.

FROM MICHIGAN SEED ANALYSES, 1912.

Noxious Weed Seeds Found in Commercial Seeds.

Name of Weed.	Alfalfa.	Alsike Clover.	Red Clover.	White Clover.	Timothy.	Lawn Mixtures.
Number of samples	199	44	114	6	33	15
Quack grass	1	..	..	..	1	..
Charlock	9	..	1	..	..	4
Indian mustard	5	..	..	..	..	..
Black mustard	5	..	..	..	..	..
False flax	..	..	..	..	..	2
Canada thistle	..	4	5	1	3	4
Chicory	8	..	2	..	..	..
Oxeye daisy	1	2	..	..	1	4
Dodder	16	..	3	1	..	3
Wild carrot	..	..	1	1	..	1
Orange hawkweed	..	..	..	..	..	..

Butter and eggs	..	..	..	..	..	..
Buckhorn	15	8	84	4	2	10
Rugel's plantain	..	2	46	1	3	9
Night-flowering catchfly	4	6	5	..	..	1
Pennycress	..	..	..	1	..	..

Other seeds of weeds, not regarded in Michigan as noxious, found in this same set of samples are as follows:

Alfalfa: Yarrow, yellow alyssum, tumbleweed, rough pigweed, ragweed, burdock, yellow foxtail, green foxtail, sand bur, lamb's-quarters, hare's-ear, field bindweed, barnyard grass, gum weed, sunflower, mallow, white sweet clover, tickle grass, switch grass, knotgrass, knotweed, wild buckwheat, smartweed, black-eyed Susan, field sorrel, yellow dock, Russian thistle, crab grass, nettle.

Alsike Clover: Chickweed, tumbleweed, mayweed, shepherd's-purse, mouse-ear chickweed, green foxtail, lamb's-quarters, spike rush, cow cress, wild peppergrass, white sweet clover, tickle grass, rough cinquefoil, sorrel, yellow dock, tumbling mustard, crab grass.

Red Clover: Chickweed, prostrate amaranth, tumbleweed, rough pigweed, ragweed, mayweed, sandwort, mouse-ear, chickweed, yellow foxtail, green foxtail, spurge, prickly lettuce, motherwort, wild peppergrass, mullein, ray grass, mallow catnip, broom corn, millet, switch grass, bracted plantain, common plantain, smartweed, lady's-thumb, rough cinquefoil, sorrel, field sorrel, yellow dock, bitter dock, Russian thistle, sleepy catchfly, ergot, small crab grass, large crab grass, slender nettle, blue vervain.

White Clover: Tumbleweed, Mayweed, shepherd's purse, mouse-ear chickweed, wild peppergrass, common plantain, yellow dock.

Timothy: Wild peppergrass, knotgrass, smartweed, self-heal, sorrel, yellow dock, field sorrel, Russian thistle, slender nettle, blue vervain.

Lawn Grasses: Prostrate amaranth, tumbleweed, rough pigweed, shepherd's-purse, mouse-ear chickweed, fireweed, celandine, roquette, wormseed, mustard, wild peppergrass, bracted plantain, common plantain, selfheal, buttercup, radish, sorrel, yellow dock, spurry, ergot, mullein.

The summary of the data from the Iowa Experiment Station concerning the chief weed seeds found in the various kinds of farm seeds is as follows:

1913—Alfalfa: Quack grass, pigweed, ragweed, wild mustard, black mustard, knapweed, lamb's-quarters, chicory, hare's-ear mustard, dodder, crab-grass, rocket, wild geranium, marsh elder, sweet clover, old witch grass, buckhorn, smartweed, black bindweed, curled dock, Russian thistle, green and yellow foxtail, vervain, bur clover.

1913—Clovers: Wild mustard, black mustard, corn flower, lamb's quarters, chicory, Canada thistle, bull thistle, dodder, wild carrot, crab grass, spurges, wild geranium, peppergrass, horehound, Mexican dropseed grass, evening primrose, old witch grass, ground cherry, bracted plantain, buckhorn, Rugel's plantain, smartweed, cinquefoil, self-heal, horse sorrel, curled dock, green and yellow foxtail, night-flowering catchfly, corn spurrey, vervain.

1913—Timothy: Quack grass, ragweed, mayweed, Indian mustard, black mustard, shepherd's-purse, sedges, lamb's-quarters, crab grass, wild rye, spurges, squirrel-tail grass, peppergrass, evening primrose, oxalis, old witch grass, buckhorn, Rugel's plantain, smartweed, cinquefoil, wild rose, horse sorrel, curled dock, green and yellow foxtail, smut, chickweed.

1913—Alsike Clover: Shepherd's purse, lamb's-quarters, Canada thistle, crab grass, wild geranium, peppergrass, white campion, evening primrose, old witch grass, bracted plantain, buckhorn, smartweed, black bindweed, horse sorrel, curled dock, Russian thistle, green and yellow foxtail, night-flowering catchfly, horse nettle.

1906—Wheat: Corn cockle, vetch, chess, mustards, darnel.

1906—Oats: Wild oats, ragweed, mustards.

The Kentucky Experiment Station gives the following summary of their analysis of farm seeds, showing the weeds most common in the samples examined.

Kentucky Blue Grass: Peppergrass, dog fennel, sour dock, curled dock, horse nettle, rough cinquefoil, sedge, dandelion.

Timothy: Peppergrass, dog fennel, black-eyed Susan, Canada blue grass, green foxtail, witch grass, sour dock, pigweed, rough cinquefoil, buckhorn, common plantain, red-top (ergotized).

Orchard grass: Cheat, sour dock, curled dock, velvet grass.

Red Clover: Buckhorn, common plantain, dodder, bracted plantain, sour dock, curled dock, smartweed, horse nettle, crab grass, witch grass, pigeon grass, green foxtail, peppergrass, chickweed, lamb's-quarters, nettle-leaved vervain, blue vervain, milk purslane.

Mammoth Clover: Buckhorn, common plantain, bracted plantain, dodder.

Alfalfa: Buckhorn, dodder, wild carrot, pigeon grass, green foxtail, self-heal.

Dodder seeds were found in 37 per cent of the red clover samples, in 36 per cent of the mammoth clover, and in 31 per cent of the alfalfa.

Sour dock, or field sorrel, was found in 33 per cent of the red clover, in 36 per cent of the mammoth clover, in 6 per cent of the alfalfa, in 47 per cent of the blue grass, in 17 per cent of the orchard grass, and in 22 per cent of the timothy.

Buckhorn was found in 41 per cent of the red clover, in 54 per cent of the mammoth clover, in 70 per cent of the alfalfa, in 6 per cent of the orchard grass and in 5 per cent of the timothy.

These are generally regarded as the most persistent and troublesome of the Kentucky weeds.

The North Dakota Experiment Station gives the following list of the chief weed seeds as determined from the analyses of commercial seeds made in 1911-12.

Catchfly, corn cockle, crab grass, pink cockle, darnel, dock, dodder (2 species), evening primrose, false flax (2 species), Frenchweed, hare's-ear mustard, kinghead, lamb's quarters, marsh elder, Indian mustard, peppergrass, pigeon grass (2 species), plantain (3 species), quack grass, ragweed, rose, Russian thistle, smartweed, sorrel dock, sow thistle, sweet clover, Canada thistle, prairie thistle, tumbling mustard, tumbleweed, wild barley, wild buckwheat, wild oats.

The entire list of foreign seeds is not given because of its great length, but is summarized according to the farm seeds containing the weed seeds as following:

Alfalfa, 100 species; alsike, 30 species; flax, 122 species; oats, 40 species; wheat, 62 species; brome grass, 103 species; red clover, 97 species; millet, 43 species; timothy, 90 species.

This seems to indicate more species of weeds present in North Dakota than in some of the other states, judging from the data at hand.

Lists of the worst weeds which infest red clover, sweet clover, meadow fesque and alfalfa have been made from data collected at the Kansas Experiment Station during the eighteen months from Jan. 1, 1913, to July 1, 1914.

Red Clover—80 Samples: Dodder, 11 samples; buckhorn, 33 samples; black bindweed, 4 samples; star thistle, 2 samples; Russian thistle, 2

samples; cheat, 1 sample; black mustard, 1 sample; charlock, 1 sample; Canadian thistle, 1 sample; crab grass, 26 samples; curled dock, 36 samples; wild lettuce, 1 sample; bull thistle, 2 samples; smartweed, 17 samples; sour dock, 13 samples; dock, 4 samples; pigeon grass, 30 samples; barnyard grass, 8 samples; catchfly, 6 samples; pigweed, 16 samples.

Meadow Fesque—56 Samples: Cheat, 48 samples; quack grass, 1 sample; buckhorn, 7 samples; dodder, 6 samples; curled dock, 34 samples; bearded plantain, 34 samples; smartweed, 16 samples; sour dock, 7 samples; broad-leaved plantain, 1 sample; crab grass, 2 samples; foxtail, 11 samples; pigeon grass, 8 samples.

Sweet Clover—131 Samples: Dodder, 10 samples; buckhorn, 16 samples; cheat, 9 samples; Russian thistle, 32 samples; Johnson grass, 2 samples; black bindweed, 10 samples; star thistle, 1 sample; quack grass, 2 samples; roquette, 6 samples; pennycress, 1 sample; broad-leaved plantain, 3 samples; sour dock, 8 samples; smartweed, 8 samples; charlock, 7 samples.

Alfalfa—487 Samples: Dodder, 54 samples; buckhorn, 45 samples; star thistle, 33 samples; Russian thistle, 63 samples; Johnson grass, 5 samples; black bindweed, 14 samples; broad-leaved plantain, 10 samples; chicory, 17 samples; roquette, 11 samples; mustard, 8 samples; curled dock, 41 samples; sour dock, 3 samples; crab grass, 35 samples; charlock, 4 samples; bull thistle, 2 samples; foxtail, 244 samples.

One sample of alfalfa, bought for pure seed, contained a total of 2,015 foreign seeds, all of species of weeds, in the five-gram sample. This sample equals a rounded teaspoonful of alfalfa seed, and there are approximately 91 teaspoonfuls to the pound.

The following list prepared by Mrs. E. P. Harling of the Kansas Experiment Station is based on samples of Kansas wheat secured during the summer of 1914 and examined by the Laboratory of Grain Standardization of the U. S. Dept. of Agriculture located at Kansas City, Mo.

Total number samples examined, 396; free from weed seed, 101.

Lamb's-quarters found in 178 samples; peppergrass, 113 samples; sinuate-leaved evening primrose, 103 samples; green foxtail, 43 samples; panicun sp., 28 samples; knotted hedge parsley, 24 samples; strong-scented eragrostis, 23 samples; unidentified sedges, 18 samples; wild sunflower, 7 samples; lycopus, 117 samples; unidentified grasses, 12 samples; paspalum, 6 samples; yellow foxtail, 5 samples; charlock, 5 samples; fesque grass, 4 samples; tick seed, 3 samples; curled dock, 3 samples; barnyard grass, 3 samples; cleavers, 3 samples; unidentified legumes, 3 samples; solanum sp., 2 samples; wild buckwheat, 2 samples; Russian thistle, 2 samples; polygonum sp., 2 samples; malva sp., 1 sample; dock, 1 sample; bitter dock, 1 sample; yellow wood sorrel, 1 sample; lady's-thumb, 1 sample; blunt spike rush, 1 sample; willow herb, 1 sample; crab grass, 1 sample; prairie bird's-foot trefoil, 1 sample; wild oats, 1 sample; millet, 1 sample; Fremont's goosefoot, 1 sample; knotweed, 1 sample; bracted plantain, 1 sample; unidentified seeds, 11 samples; ergot, 3 samples.

Some Facts About the Vitality of Weed Seeds.

(Kansas Experiment Station.)

Dodder seed will live for five years in the ground, germinating at any time conditions are favorable. Each dodder flower has four seeds, often sixty flowers in a cluster, and the number of clusters almost unlimited; the seed from one plant will often

take every host plant within a square rod. If one tiny strand of dodder be dropped within reach of a host plant, it immediately seizes upon it and begins a new life. Experiments from Washington show that dodder will mature seed which in its turn will mature seed all in one season.

Almost half of ten-year-old buckhorn seed grew.

One hundred per cent of cuttings one-half-inch long, from the next to the smallest thread roots of the Canadian thistle grew.

The sure way to destroy the vitality of weed seeds is to let them lie a number of months in the compost heap, as none will grow after the heap has thoroughly fermented.

The following list from the Maryland Experiment Station shows the relative size of the seeds of some of the common field weeds and farm plants. It illustrates the importance of having farm seeds free from even a small weight percentage of weed seed, as with some species of weeds a fractional per cent of weed seed means the scattering of millions of the very minute seeds.

Plant	No. seeds in 1 pound.
Corn	1,308
Wheat	11,250
Crimson clover	132,000
Alfalfa	226,000
Red clover	272,000
Millet	272,160
Japan clover	420,000
Sheep's fesque	498,000
White clover	830,000
Yellow lupine	4,528
Great ragweed	10,000
Morning-glory	16,500
Cockle	57,000
Jimson weed	66,000
Mallow	237,000
Sweet clover	271,000
Crab grass	1,088,000
Blue vervain	1,909,000
Pigweed	2,260,000
Shepherd's-purse	6,496,000

Another interesting set of data which supplements the former table by showing what reproductive power is inherent in these weed seeds, has been gathered by Mrs. Harling of the Kansas Experiment Station, and gives the number of seeds matured by the individual plant in a number of the species.

	Seeds.
Field bindweed	120
Quack grass	400
Prickly sida	400
Bindweed	600
Cheat	1,000
Urena	1,000
Careless weed	1,000

Wild mustard	1,200
Wild carrot	1,200
Chicory	3,000
Florida clover	6,000
Charlock	4,000 to 110,000
Canadian thistle	3,500
Ironweed	7,000
Cocklebur	9,700
Sour dock	10,000
Curled dock	17,000
Peppergrass	18,000
Sow thistle	19,000
Orange hawkweed (1st crop)	12,000
Ragweed	23,000
Oxeye daisy	13,000 to 26,000
Velvet leaf	31.900
Sand bur	42,700
Dandelion	2,000 to 53,000
Shepherd's-purse	50,000
Crab grass	86,000
Jimpson weed	29,000 to 66,400
Evening primrose	300,000
Pennycress	each pod 6-12 seeds; unlimited number of pods.

Some interesting data are available from a thesis written in the University of Wisconsin in 1913 by Anton John Zahorick on "Impurities as a Determining Factor in the Origin of Agricultural Seeds." This thesis was loaned to the University of Chicago Library through the courtesy of the library officials in Madison.

The writer of the thesis obtained samples of commercial seeds from all parts of the world through the assistance of the U. S. consuls. These samples were analyzed, and the data obtained tabulated in various ways, as (1) the source and name of the sample and the weed seed contained therein; (2) the foreign seeds found in the samples of agricultural seeds; (3) the combination of foreign seeds which may be used to determine the continent from which the commercial seeds come.

The following lists and tables are derived from the material given in the thesis.

The following table shows the distribution of the various weed seeds found in the wheat samples examined.

Name of Weed.	Canada.	Chile.	Uruguay.	Austria.	Germany.	Great Britain.	Roumania.	Sweden.	Switzerland.	China.	India.	Turkey.	New Zealand.
Quack grass	*	..	..	..	*	..	..	..	..	..	..	..	..
Corn cockle	*	..	..	*	..	*	*	..	..	..	..	*	..
Wild oats	*	*	..	*	..	..	..	..	..	..	..	..	*
Indian mustard	*	..	..	..	..	*	*	..	..	*	..	..	..

Green foxtail	*												
Lamb's-quarters	*												
Hare's-ear mustard	*			*									
Wild sunflower	*												
Sticktight	*						*						
Ball mustard	*			*									
Bracted plantain	*												
Black bindweed	*			*		*	*		*				*
Night-flower'g catchfly	*												
Pennycress	*			*									
Charlock		*		*		*	*		*				
Field bindweed		*		*			*					*	
Field dodder		*											
Wild radish		*				*							
Hairy vetch		*		*			*			*			
Thyme-leav'd sandw'rt				*									*
Eng. rye grass			*			*							
Darnel			*									*	
Curled dock			*			*	*		*				
Bugle				*									
Kidney vetch				*									
Chess				*	*		*						
Small Seed'd false flax				*									
Bull thistle				*									
Yellow foxtail				*									
Wild carrot				*					*				
Field larkspur				*			*						
Cleavers				*		*	*	*	*			*	
Corn gromwell				*			*						
Cowwheat				*									
English plantain				*					*				
Lady's-thumb				*	*								
Dyer's rocket				*									
Broom corn millet				*									
Hawk's-beard					*								
White clover					*								
Spring vetch				*	*	*	*			*			*
Rough pigweed							*						
Pope's sand parsley							*						
Canada thistle							*						
Barnaby's thistle							*						
Goosefoot							*						
Hemp nettle							*						
Field peppergrass							*						
Mallow							*						
Yellow trefoil							*		*				
Sweet clover							*						
Knotweed							*						
Cowherb							*						
Rough-stalked meadow grass								*					
Sweet vernal									*				
Tall meadow oat grass									*				
Brome grass									*				
Meadow fesque									*			*	
Canary grass									*				
Annual meadow grass									*				
Forked catchfly									*				
Creeping buttercup									*				
Rape											*		
Peppergrass												*	
Cow cockle												*	

The most widely distributed weeds according to these data are: Black bindweed and cleavers in six countries each; corn cockle, charlock and spring vetch in five; and wild oats, Indian mustard, field bindweed, hairy vetch and curled dock in four. There is no evidence that there were enough samples of wheat from each country from which to formulate a general statement. The variety of weeds would have been much greater if some of the grass seeds or alfalfa or clover were compiled with the wheat data in this table.

Foreign seeds which will determine the continent from which the commercial seed comes if all of them are combined in one sample are as follows:

North America: Wild saltbush, sand bur grass, poverty weed, tall smooth panicum, blue vervain, cycloloma, gum weed, marsh elder, Russian thistle, sinuate-leaved evening primrose.

South America: Corn cockle, pigweed, mayweed or dog fennel, wild oats, Indian mustard, chess, bull thistle, Barnaby's thistle, lamb's-quarters, chicory, field bindweed, wild carrot, peppergrass, darnel, witch grass, English plantain, black bindweed, wild radish, curled dock, spring vetch, tumbling amaranth, ragweed, thyme-leaved sandwort, charlock, rape, barren brome grass, sedge, green foxtail, goosefoot, poison hemlock, clover dodder, meadow fesque, English rye grass, yellow trefoil, pearl grass, black-seeded plantain, Lady's-thumb, sheep sorrel, common tansy, hairy vetch.

Europe: Yellow alyssum, kidney vetch, shepherd's-purse, smooth hawk's-beard, field larkspur, fall dandelion, poppy, annual meadow grass, rabbit's-foot clover, pansy, field camomile, tall meadow oat grass, cornflower, crested dog's-tail, hemp nettle, sainfoin, plantain, knotweed, corn salad.

Asia: Red pimpernel, goose grass, indigo, einkorn, smaller burdock, cotton fenugreek.

From Oceanic Countries: Yarrow, thyme-leaved sandwort, soft chess, barren brome grass, yellow foxtail, lamb's-quarters, smooth hawk's-beard, orchard grass, roquette, sheep, fesque, chickweed, wild oats, chess, mouse-ear checkweed, green foxtail, goosefoot, crested dog's-tail, wild carrot, meadow fescue, rat's-tail fescue, cut-leaved crane's-bill, cat's-ear, flax, yellow trefoil, knotweed, lady's-thumb, curled dock, spiny sow thistle, corn spurry, spring vetch, velvet grass, nipplewort, mallow, English plaintain, field bindweed, sheep sorrel, forked catchfly, annual sow thistle, hop clover, hairy vetch.

Following is given the distribution of certain common weeds in grain samples from different parts of the world.

SEED.	COUNTRY FROM WHICH OBTAINED.
	I. Charlock or Wild Mustard.
Oats	Wales, Germany, Turkey.
Meadow fesque	Germany.
Meadow grasses	Wales.
Barley	Scotland, China, Chile.
Alfalfa	Hungary, Germany.
Timothy	Austria, Germany.
Crimson Clover	Germany.[3]
Red clover	Sweden[1], Germany, France, Austria.
White clover	Germany, England.
Wheat	Roumania[6], Chili, Austria[3], Germany, Wales, Hungary.

Seed.	Country From Which Obtained.
	II. Canada Thistle.
Barley	Wales.
Alfalfa	Hungary.
Timothy	Canada[2], Germany.
Rye	Russia.
Alsike	Russia, Sweden, Canada.
Red clover	Austria, Japan.
Wheat	Roumania[2].
	III. Corn Cockle.
Oats	England, Austria, Sweden.
Buckwheat	Belgium.
Flax	Argentina.
Timothy	Austria.
Rye	Austria, Scotland.
Wheat	Russia, Scotland, Canada, Austria[2], Turkey, France, Hungary, Roumania.
	IV. Mouse-ear Chickweed.
Oats	New Zealand.
Barnyard grass	India.
Meadow grass	Germany, Belgium.
Velvet grass	Germany.
English Rye Grass	New Zealand, Germany, England.
Timothy	Canada, Sweden.
Alsike	Canada, Germany, England, France.
White clover	Germany[2], New Zealand, England, Wales.
Wheat	Sweden.
	V. Yellow Foxtail.
Buckwheat	Austria.
Meadow fescue	Germany.
Barley	Wales.
Flax	Argentina, Uruguay.
Alfalfa	Germany, Greece, New Zealand.
Millet	India, Japan.
Red clover	Germany, Austria.
Wheat	Austria, Hungary.
	VI. Forget-me-not.
Brome grass	Germany.
Orchard grass	Austria, Hungary, Germany.
Meadow grasses	Belgium, Canada, Ireland, Germany.
Italian rye grass	Switzerland, Germany.
English Rye Grass	Denmark, England, Switzerland, Germany.
Timothy	Austria, Germany.
Rye	Russia.
Red clover	Austria, Russia.
White clover	Germany, France, England.
	VII. English Plantain.
Oats	Switzerland, Wales.
Orchard grass	Germany.
Barnyard grass	India.
Meadow grass	Ireland.
Meadow grasses	Canada, Wales, Belgium, Germany.
Italian rye grass	England, Germany.
English rye grass	Germany, Belgium, Denmark, England, Switzerland.
Alfalfa	Germany[2], France, Hungary, Switzerland, Austria, New Zealand.
Millet	India.
Timothy	Germany and Austria.
Rye	Russia.

Seed.	Country From Which Obtained.
Alsike	Germany, Russia, New Zealand, France, England.
Red clover	Canada, Chile, Germany, Austria, Russia, New Zealand, Belgium, England, France, Switzerland.
White clover	Germany, New Zealand, England, Russia.
Wheat	Wales, Hungary.

VIII. Field Bindweed.

Oats	Austria, England, Wales, Scotland, Ireland, New Zealand.
Barley	Scotland, Wales, Denmark.
Flax	Uruguay, Argentina.
Alfalfa	Hungary, Austria.
Red clover	Austria, Sweden.
Rye	Scotland.
Wheat	Roumania, Austria, Sweden, Wales, New Zealand, Ireland, Hungary, Canada, Switzerland.

IX. Curled Dock.

Oats	Chile, Scotland.
Orchard grass	Germany, Austria.
Meadow grasses	Canada.
Barley	Wales, Chile, Denmark.
Flax	Germany, Argentina.
Alfalfa	France, Germany, Hungary, New Zealand.
Sweet clover	Australia.
Timothy	Germany, Canada.
Clover	India.
Alsike	Canada, Switzerland.
Red clover	Chile, Sweden, England, Germany, Belgium, Canada, New Zealand, Austria.
White clover	England, Germany, Russia.
Wheat	Roumania, Uruguay, Wales.

X. Penny Cress.

Buckwheat	Austria.
Italian rye grass	England.
Timothy	Austria, Canada.
Millet	Germany.
Alsike	Sweden.
White clover	Wales, England.
Wheat	Hungary.

Reports and Bulletins on Farm Weeds.

U. S. Bulletins: 28, 660, 368, 545.

Canada: *Farm Weeds of Canada,* Govt. Report.

Michigan: State Agricultural Experiment Station, *Bulletin No. 270.*

Iowa: Agricultural Experiment Station, *Bulletins 88 and 146.*

N. Dakota: Agricultural Experiment Station Extract from *22nd Annual Report, 1912.*

Kentucky: Agricultural Experiment Station, *Nineteenth Annual Report, 1906; Bulletins 127 and 183.*

Kansas: Data from analysis of seeds at Kansas State Agricultural College, Manhattan, Kan.

Maryland: Agricultural Experiment Station, *Bulletin No. 155.*

RECENT TENDENCIES IN HIGH SCHOOL CHEMISTRY.

By Robert H. Bradbury,

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I.

Let me first refer, very briefly, to propositions which affect the position of chemistry in the course and the amount of time devoted to it. On account of the great industrial importance of the science and of the high probability of its being of value to the student after his school-days are over, there has been a widespread demand that chemistry be started earlier in the course—e. g., in the second year—and that two years of it be given. Since chemistry is, at present, usually given only in the fourth year, it follows that approximately two-thirds of the million high school students of the country leave with no knowledge of chemistry whatever. This seems an unfortunate method of handling a science which is perhaps the most immediately useful subject of the whole curriculum.

Further, we need continuation courses in the sciences because they will improve the character of the work. As Dewey has pointed out, in a memorable essay[1], the excellent results undoubtedly obtained by the study of Latin in high schools are probably due less to the subject matter of the instruction than to its method. Latin runs through the whole four years. The first year student knows—or can be effectively convinced—that if he neglects his Latin he will be all at sea in it during his second year. The second-year student has the salutary pleasure of using his first year Latin[2] as an instrument of further achievement. The same statements hold good, with cumulative force, for the third and fourth years.

Let us follow Dewey a little further in setting up an imaginary linguistic curriculum, which shall parallel, as closely as possible, our present arrangements for the sciences. It would run somewhat as follows:

"The time devoted to each language is about four hours a week for forty weeks. Latin is finished the first year, French the second, German the third, and Spanish the fourth. Similar courses are offered, as electives, in Greek and Italian."

Supposing that this curriculum were offered, in all seriousness, to a representative group of high school language teachers,

[1]Dewey, "Science as Subject Matter and as Method," *Science*, Vol. 31, p. 121 (1910).

would they accept it? Would the herald who voiced the proposed change escape with his life from the fury he had provoked? And would not the teachers be absolutely justified in their enthusiastic rejection of such a proposition? Yet each science offers, to the student, a far greater task than each language. An earnest student can obtain, without overwork or hardship, a substantial reading knowledge of French in about three months. This is not the sort of knowledge that will fit one to teach a language, but it is the key of the treasure-house of French literature and French science. How much chemistry or physics can one learn in three months? Why are we so much more generous in our allowance of time to the languages than to scientific subjects?

Finally, it is well to point out that the strong movement to establish a generalized science course in the first year has a very definite bearing upon the question we are discussing. Something like a third of the time appropriated to general science would naturally be spent upon the fundamental conceptions of chemistry, and the ideas thus gained would add greatly to the efficiency of the chemical work of the later years.

II.

We turn now to the consideration of those suggestions which affect the method and subject matter of chemical teaching. Here the chief tendency that calls for comment is a somewhat insistent demand that the "theory" be cut out of the courses, that the work be made more "practical," or that the subject be "brought close to the lives of the pupils."

Sir Wm. Hamilton, with his usual penetrating insight remarks that the "word 'theory' is used in a very loose and improper sense by English writers." In fact the word is often employed with great freedom by people who become embarrassed when they are asked to explain exactly what they mean by it.

Perhaps the most frequent significance attached to the word is that of a hypothesis which, on its way to take rank as a fact, has achieved such a measure of probability that it is entitled to be promoted into a kind of special class of near-facts, so to speak. In order to test this meaning, let us glance at an example, adapted from Huxley.

A man is sitting quietly by a window. Various sounds, sight-sensations and perhaps odors affect him and, because they do

[2]Dewey, loc. cit., p. 124.

not concern him, he gives them only a languid attention. Suddenly he becomes aware of an odor of wood-smoke. This being, potentially, a matter which does concern him, he is aroused to attend to it and thinking begins. This thinking takes the form of constructing hypotheses to account for the odor. His neighbor may be lighting a fire or some one may be burning brush in the street. These being of no special interest, it does not occur to him to verify them, but a third hypothesis which flits across his imagination is of such importance that it must be tested at once. He recalls that a few minutes ago he withdrew the ashes from his furnace into a wooden box. The ashes were hot, and he is disturbed by the possibility that the wood has been kindled by a glowing ember.

At this stage he disappears down the stairs, with a speed which can be calculated from the laws of falling bodies, and his subsequent proceedings interest us no more. If he finds the cellar in flames he can reflect, with pride, that his hypothesis has withstood the test of experience. True, hypothesis, the tadpole, has here, in our presence, acquired legs, dropped his tail and become a fact, but at what stage was the thing a theory? Did it not remain a hypothesis until, in a moment, it was transformed into a fact?

There is, in the evolution of a tadpole, a stage in which, though he has acquired legs, he unwisely holds on to his tail, and functions, for a time, as a monster of most displeasing appearance. This would be the biological analogue of a theory, but I am not aware that a hypothesis, in its transformation into a fact, passes through any stage of this kind.

A second sense in which the word "theory" is used is to designate those portions of a science which cannot be directly employed in earning a living. In that case, cutting out the theory would mean the elimination of the entire curriculum with the possible exception of certain commercial branches. Other meanings there are in plenty, but we cannot delay to deal with them. Let us rather drop the word altogether, since it seems to have become a mere instrument of intellectual confusion. Hypothesis we know—it means a guess. And fact we know—it means a hypothesis which has proved to be correct. But theory means nothing. It is merely a term which people apply freely to any difficult subject which they do not understand and of which they cannot grasp the importance.

III.

Looking at the matter from the more positive point of view of the recommendation to make the work more practical, we find, fortunately, that this desire has received concrete expression in several tests, which are worthy of careful study. They begin with a hundred pages of formal chemistry given in a purely didactic way. This portion is a kind of highly condensed and abstract grammar of chemical science and is apparently offered in the hope that the student will be able to apply the principles in the work that follows. The remaining pages are devoted to such subjects as lime, cement, pottery, inks, electric furnaces, pigments, etc. In fact, the books are, to all intents and purposes, elementary chemical technologies.

Here, then, is a definite constructive plan, for rendering our work more practical, fully worked out. We have merely to cut down the chemistry to an introductory course, and spend the time upon technology. But, as a matter of fact, is a mass of more or less accurate information about technology likely to prove of greater value to the student than a knowledge of the scientific aspect of the subject? Will he ever need to make his own ink or his own pottery? In the scientific type of text, the student, under calcium carbonate, learns something of the effect of heat upon it and of the interesting dependence of the process upon the concentration of the carbon dioxide in contact with the solid. Here we have, instead, a two-page description of the manufacture of lime in a rotary kiln. Is not the hypothetical, practical character of this kind of knowledge a pure illusion? Of course, the fact that lime is not really made in rotary kilns is an unfortunate accident, but even if it were, in what way could the student make any actual use of his knowledge of the process?

This leads to the remark that the technology, in the texts which feature that subject, is apt to be inaccurate. It is most difficult for a textbook writer to be sure of his technology. The technological journals do not speak with the authority of the journals devoted to pure science. They contain numerous articles which are written for advertising purposes and which must be read with great caution. The real methods by which results are obtained are often carefully kept secret. To quote from a review: "The technology of the average elementary text is a species of museum, in which processes discarded elsewhere are preserved forever, like insects in amber."

But even if the author of a book of this type should succeed

in making the technology accurate, it would not long remain so, for technology changes with astonishing speed. I have known chemical manufacturers to object to the permanency of concrete buildings because their solidity introduced difficulties when it became necessary to "scrap" the plant to keep pace with progress. We should firmly grasp the fact that in changing from chemistry to technology, we are deserting knowledge of proved permanent worth to deal in information whose chief characteristic is the evanescence of its value. The technology we teach now will merely mislead our students ten years hence, unless they have been able to keep up with the progress of the subject.

There is another important point which is commonly lost sight of by those who insist that we should confine our teaching to the applications. Technology is simply applied science. "There can be no applied science without science to apply." To teach nothing but the applications would sterilize chemistry and destroy the possibility of progress. The applications themselves would at once stagnate. The disinterested research of today is tomorrow the basis of an industrial process and is directing the production of the luxury or the necessity of thousands. Pure science is the most intensely practical of all human activities. Those who sneer at it are ignorant of history. In about a century it has transformed the conditions of human existence and its work is hardly begun. It is the only occupation worthy of a man who desires to benefit the world as much as possible by his residence in it. Science is by far the greatest of all the forces working toward the material and mental uplift of the people. A child who gives up four years to a higher education has a right to as much of it as we can give in the time—all too short—at our disposal. And I may digress for a moment to remark that it seems to me little short of robbery to waste his course with chickenfeed of the fruit-spot, ink-spot, grease-spot, garbage-can type—a proceeding which leaves him, at the end, ignorant of chemistry, but the fortunate possessor of a few bits of household information, which he could obtain from any intelligent woman in five minutes.

If, then, technology is really no more useful to the student than chemistry, if the technology of those elementary texts which specialize in it is often quite hopelessly inaccurate, and if, even when accurate, it does not "keep," I hold that it would be a bad blunder to eliminate our chemistry and to substitute for it a scrappy mass of information about technical processses. Such

a course would be perfectly incoherent. It would have no beginning, no logical development and no end, and would lead nowhere.

Yet technology has an important place in the course, but its place is subordinate. The wise teacher will vitalize his work by constant brief references to the applications. He will keep the tremendous industrial importance of chemistry continually before his students, but he will do this without discarding the main object. The proposition to omit chemistry from the high school curriculum and to substitute elementary technology for it is merely another instance of that muddle-headed worship of the word "practical" which is the bane of Anglo-Saxon thinking.

IV.

Glancing now at the third slogan—"Bring the subject closer to the lives of the pupils," we must admit that this rather vague expression has a content of fact that is well worth noting. The essence of good teaching is to proceed from the familiar to the unfamiliar, from the concrete to the abstract. Chemical facts are all about us. The beginner has an abundant supply of them stored up from his daily experience, though he does not recognize their chemical character, until his attention is directed to the point. It is a matter of first-rate importance to utilize this information which he already possesses as a foundation for the structure we are trying to build. This leads to a copious use, especially at the outset, of materials drawn from the daily life of the students. Each subject should be started, if possible, with something familiar and concrete to the beginner.

I admit freely the difficulty of this. As Alexander Smith says—"We cannot possibly confine ourselves to common materials in attempting to teach the science. We simply cannot summon it forth from a mass of information about cooking, agriculture, rusting and photography by any legerdemain." It is also true that the strength of the appeal depends upon the character of the experience of the student. Prof. Whitsit remarks that most of his beginners live in small flats where everything is operated by push buttons and where there is an utter lack of chemical data. Physics is more fortunate than chemistry, so far as this question is concerned. Allowing full weight to these difficulties, the fact remains that the available experience of the beginner is a most important element in the work and that the teacher's success will be nearly proportional to his ability to ap-

peal to it—to make his teaching homely, rather than didactic and academic. And, when there is nothing to appeal to, we have to create new experience with the mineral collection, the lecture experiments and, best of all, in the laboratory.

Take the subject of the atomic weights, for instance. They are the very foundation of our science. It is the chief peculiarity of chemistry that it achieves simplicity by operating with different weights of the elements, instead of basing its reasoning upon unit weight, as do the other sciences. There is no subject more important than the atomic weights and none more difficult if we do nothing but talk about them. But there are at least four atomic weights which can be determined by the beginner in about 60 minutes with the simplest apparatus and with an accuracy of at least one unit. After the student has done this work, his difficulty in handling the atomic weights disappears. They have become concrete to him and he uses them in his calculations with perfect appreciation of their significance.

V.

It is surprising to find that the fundamental axiom of good teaching—"from the familiar to the unfamiliar, from the concrete to the abstract"—is violated at all points by the order of topics which is still largely in use in presenting chemistry to the beginner. The current order seems, indeed, to lay stress on starting with the unfamiliar, since it begins with such wholly abstract subjects as matter, energy, molecules and atoms, and since unfamiliar substances are hurled at the student by the dozen at the very outset. It will be obvious that the plan of giving abstract general concepts to the beginner at the start, when they are entirely unintelligible, with the hope of using them later, is foredoomed to failure. Such concepts should be introduced naturally in the course of the work, as the need for them arises, and when the student has the experience which renders them intelligible. And the use of substances strange to the student as examples of such processes as solution and crystallization should be avoided. These things can be much better explained by instancing sugar and salt than by bewildering the beginner by reference to copper sulphate, potassium chlorate and carbon disulplide. We are prone to forget that the chemical names which are so simple and full of meaning to the teacher are, at the outset, mere bizarre jargon to the beginner. The student must, of course, be made acquainted with these substances, and

with many others, but they should not be introduced until the proper stage has been reached for their full discussion. To attempt to explain a new concept, like solution, by referring to the behavior of a totally unfamiliar substance, whose very name the beginner cannot pronounce, is to destroy all chance of comprehension. The more homely the instance, the better. The student who has watched the behavior of the sugar in a glass of lemonade has started on the path which leads to the peak whence he can view the territory opened up by Raoult, Arrhenius and van't Hoff in all its spaciousness.

Another bad defect in the usual order of topics is that the earlier part of the work is concerned almost entirely with colorless invisible gases. The only gases the beginner knows are air and illuminating gas, both of which are complex mixtures. Much later in his work, he is profoundly surprised and interested when told that anything so unsubstantial as air can be converted into a liquid. Of a gas as a special form of a single pure substance he has no conception whatever.

At this time the beginner is grappling with ideas which are new and difficult to him and which are indispensable to his mastery of the subject. The foundation offered to him for the struggle is almost ideally bad. The experimental evidence consists chiefly in changes in the level of liquids in certain graduated glass tubes which the teacher, very wisely, will not allow him to touch. The experiments are impossible in the laboratory and in the class-room the student cannot read the graduations, and has to take the results on faith.

Take the electrolysis of water. The experiment is dramatic and it always interests the students, but interest, though a necessary condition of success, is not sufficient to it. Question the class a week later. How many have clearly perceived the fundamental fact that every bubble of gas means that an equivalent amount of water has disappeared? This point is in no way brought out in the experiment. Many students imagine on the contrary, that additional water is formed, because of the rise of the level of the liquid in the funnel-tube. How can one explain to them at this stage, or even later, the function of the sulphuric acid? How shall we prove to them that the gases really come from the water, the acid remaining unchanged? And if they are willing to take all this on faith, the only addition to their intellectual equipment is the proposition that when an indefinite and unperceived mass of water disappears, two parts of hydrogen

and one part of oxygen make their appearance. From this, they will at once draw two conclusions:

1st. That water contains twice as much hydrogen as oxygen, whether by volume or by weight is all one, as far as they are concerned, for they do not distinguish clearly at this stage.

2nd. *Therefore,* the formula of water is H_2O. Thus they lay the foundation for a comprehensive misunderstanding of the meaning of chemical formulæ, from which it is very difficult to free them later. Ohmann is absolutely right in his contention that this important experiment should be deferred and taken up much later, in connection with sulphuric acid, ionization and electrolysis.

As a contrast to this, consider the heating, by the student himself, of a gram or so of fine copper wire with sulphur in a closed porcelain crucible. The copper and sulphur have unmistakably vanished. The new gray-black product is visible, tangible and *weighable,* and the increase in weight happens, fortunately, to be almost exactly one-fourth of the weight of the copper taken. We have, in other words, a rock foundation for the beginner's feet, as compared with a quicksand.

A rational order of topics would start with familiar solids, like copper, lead, tin and sulphur. It would settle the all-important question of *combination by weight,* before attempting to elucidate the behavior of gaseous molecules, and it would settle this question by experiments which the student could carry out for himself.

It will be seen that the question whether the work should be quantitative or qualitative is one which carries with it its own answer. The laboratory work is not to be regarded as a thing apart. The course has often been compared to a pattern woven of many threads, and most of these threads can originate only in the laboratory, the great object of which is to furnish the sense-experience with which alone the weaving can be accomplished. To make the work all quantitative leads to narrowness and to serious loss of time. On the other hand, to omit all quantitative experimentation deprives the student of all basis for his reasoning and introduces almost insuperable difficulties in the way of teaching the subject. As a tentative suggestion, it may be remarked that a laboratory course in which one-third of the experiments are quantitative lends itself readily to definite interrelation with the class-room work and develops good manipulative habits in the students.

The dominant motive in a rational arrangement of the work is the effort to develop each topic out of some concrete familiar instance, so that the matter will be significant to the student from the start. Success depends mainly upon constant attention to this principle. The difficulties in the way have been briefly referred to. Daily life often leaves us in the lurch, but when this happens, a mineral or a well-executed laboratory experiment is an excellent starting point.

Almost no weight can be attached to systematic chemical classification in the arrangement of elementary work. To group gold and silver with sodium, manganese with chlorine and chromium with sulphur, hoping that the beginner may reap some benefit later, is a waste of time. Even to the chemist such groupings are not wholly satisfactory, and to the beginner they are altogether artificial and unreasonable. The only families which should receive detailed consideration are those in which the analogies are quite unmistakable, especially the halogens and the alkali metals. The most important task in the reorganization of high school chemistry is to rid the work of the procrustean influence of chemical classification, which, after all, is unintelligible without a considerable knowledge of the rare elements. At the end of his course the beginner will not know the names of elements, a rather detailed knowledge of which is essential to the understanding of the classification according to which his work has been arranged. We have come from the universities and taught our students as we were taught and the plan does not work well, for the standpoint of the students and the objects of the work are different.

VI.

In a recent examination for candidates for teacherships in high schools, the question was asked whether the simple formula H_2O applies to ice, to liquid water, or to steam, with a request for a statement of the reasons for the answer. The effect of this innocent query upon the candidates—university and technical school graduates mainly—was appalling and the examiner might well have been charged with making the questions too difficult. Yet it is plain that anyone who is unable to reply intelligently to this question is in a condition of almost complete ignorance with regard to the meaning of the formula and the foundations upon which it rests.

This is a striking instance of a remarkable peculiarity of chemical instruction, not only in high schools, but in higher in-

stitutions. I refer to the stress laid upon subject matter and the neglect of method. Everywhere the object of the work seems to be to give the student a highly condensed account of the results of the science, without much reference to the method by which its results have been obtained. Whether this is wise or not, is a question which deserves much more careful consideration than it has hitherto received. I should be the last to deny the usefulness of chemical information. Yet it is difficult to avoid the conclusion that, to most people, some conception of scientific method is far more important. The possession of a large amount of information does not alone make a man educated. Education consists rather in the attitude of mind which enables a man to differentiate information from misinformation, and to understand what evidence he ought to require, before giving his assent to a proposition which may at any time assume first-rate importance as a guide to conduct. This attitude is almost as far removed from mere blank Pyrrhonism as it is from unreasoning credulity. Its chief constituents are a willingness to examine the evidence for any statement, a rooted objection to accepting any statement without evidence and, finally, the ability to estimate correctly the value of the evidence. It is almost identical with what is commonly called "good judgment' which is a very different thing from technical knowledge. The man who has judgment but who lacks the specific knowledge necessary to solve a problem which confronts him can usually make up his deficiency either from books or from other men whose business it is to possess the knowledge which he needs, but the man of wide knowledge, who lacks judgment, will, in spite of his learning and often because of it, flounder into one disastrous error after another his whole life long. All of us have known men who, with little technical knowledge, have yet achieved success. The study of such a man will invariably show that, along with aggressive energy, he possesses in unusual degree, the power to appraise quantitatively the considerations for and against a given course of action. His acquaintances usually recognize the presence of this ability by consulting him about their own problems. And the term "foresight," by which they often designate his special faculty, serves notice upon us that we are dealing with that familiar effort to predict the future from the past which constitutes the pretense of the charlaton, the main business of science, and the chief element of success in common life.

The study of chemistry purely as subject-matter is not the best

method of acquiring knowledge, and it does absolutely nothing to cultivate the judgment. It may perhaps be objected that such qualities as energy and judgment are innate, but this is merely begging the question. Those who have observed the great development of both energy and foresight which often occurs in a man who is suddenly subjected to new and increased responsibilities will hardly be disposed to assent to the hypothesis of their innateness. How do we know what qualities are innate and what can be cultivated? Perhaps no mental attribute is altogether innate. I admit that the power in question—to marshal the available data in an orderly way, to state the problem with precision, and to construct hypotheses which are usually verified by the sequence of events—seems like part of the very fibre of a man's personality, but this is merely because he is using it so continuously that it becomes part of our conception of him. On the other hand, his ability, say, to analyze our iron ore with exactness is only occasionally brought into play and impresses us, therefore, as something extrinsic and acquired.

It is interesting, also, to speculate upon the biological aspect of the question. Biologists seem, with reason, to be agreed upon the proposition that acquired characters are not inherited. Assuming that we may invert this thesis, the exceptionally foolish and useless sons, who often appear in the families of men of commanding ability in financial and industrial directions, lend no support whatever to the assumption that qualities like energy and foresight are innate. And that it is worth while to consider these qualities in our scheme of science teaching is indicated by the fact that the men at the helm in all great enterprises—while they may, and often do possess astounding technical knowledge—are hired chiefly for their foresight and for their ability to get things done.

I trust that no one will imagine that I am trying to depreciate scientific knowledge. In an industrial civilization, continually growing more complex, the importance of special knowledge is sure to increase, and this is particularly true of chemistry and physics. But it seems to me that to give some attention to scientific method, along with the subject matter, would give our courses coherence and vitality and would greatly increase their interest and value.

A MATHEMATICS CONTEST—ITS RELATION TO THE GENERAL PROBLEM OF INDIVIDUAL DIFFERENCES.

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University High School, Chicago.

It is a remarkable fact that teachers of academic subjects have never made use of the interscholastic competitive element which is admitted to be a powerful stimulus to effort in athletic contests. An athletic contest develops enthusiasm and ability to the highest degree on the part of the contestants. The question arises whether such contests are equally effective in a purely academic subject, e. g., mathematics.

The writer attempted to answer this question by devising a contest between teams chosen from first-year mathematics classes of two Chicago schools. The teams represented Hyde Park High School and the University High School. Faculty representatives of the mathematics departments of the two schools formulated the following rules to govern the contest.

I. *General Agreements:* A team is to consist of the six best students chosen from first-year classes. The department of each school chooses the captain of its team. Minimum courses shall be submitted to Professor Herbert E. Cobb of Lewis Institute who shall formulate a series of questions for a preliminary written contest of one and a half hours. Questions shall be filed in a sealed envelope with the principal of University High School on the day of the contest. The principal shall submit the questions one hour before the contest to a joint meeting of faculty representatives of the two schools. The representative of either school may eliminate all questions which are not definitely included in the course of the school represented. The teams shall meet at 3:30 p. m., May 28, 1915, at the University High School for the preliminary contest. Papers shall be graded by three prominent mathematics teachers. Judges shall not mark the papers but use score cards showing individual scores, and team totals. The team having the greater average total shall be awarded one point of the general contest. The result shall not be announced until the close of the oral contest.

II. The oral contest shall be open to the general public. Two points will be awarded. The first point is to be awarded on theory. Questions for oral contest are to be submitted by Professor H. E. Slaught, in accordance with the technique of Section I. At the time of the contest each question shall be writ-

ten on the blackboard and a definite period of time given for silent study. When a student is satisfied that he is able to present a solution of the problem he is to indicate this fact by standing. When the official timekeeper indicates the expiration of time each captain shall choose from the opponents standing, one student who is to be permitted to take his paper and place solution on the board. The teams shall alternate in presenting solutions. Judges shall grade the theory of solution presented on a basis of ten. The team whose representative makes a total failure shall be given a penalty of —2. The chairman of judges shall have the privilege of calling for a second independent solution of the same problem. He shall designate a short period of silent study and the procedure shall be the same as in the first case. This solution shall be graded on a basis of twelve. The team whose total on mathematical theory in this oral contest is the greater shall be awarded one point of the general contest.

III. (*a*) The official timekeepers shall keep a record of the total number of each team volunteering a solution for the various questions. Fifty special points shall be awarded in the ratio of the total numbers of volunteers of the two teams, e. g., if thirty-seven volunteers for University High and thirty-five for Hyde Park, then University High shall be given 25.7 points and Hyde Park 24.3 points. (*b*) The judges shall grade the written and oral expression of each team on a basis of 50.

The team gaining the larger number of points in sections *a* and *b* shall be awarded a point in the general contest.

IV. The team winning two or more of the possible three general points shall be declared the winner.

The Contest.

The try-outs for the teams absorbed for weeks the interest and efforts of every "A" student in the two schools. At Hyde Park the teachers held review contests between the various freshman sections. At University High School practice teachers divided the classes into teams and devoted a fractional part of each period for review contests. Team scores and individual scores were posted from day to day. Interest in mathematics ran high in both schools.

The oral contest was held at University High School on June 4th. The audience filled the school's largest room. Only one baseball game on the school's schedule rivaled the contest in numbers and enthusiasm. This large audience attended in spite of the fact that conditions were very unfavorable on the particular

day in question. Other school activities competed for the audience. In particular an elaborate garden party, supper, and dance followed the contest. This social affair seriously tempted a large number to remain away. In spite of this the audience "stuck" even after seemingly decisive results had been announced. It was certainly a rare and unusual educational scene of "rooting" sections with pencils and pads eagerly following the progress of the teams. The teams were not excited by the audience. There was very little evidence of nervousness after the first few minutes. The University High team averaged twelve years and three months, perhaps as young a first-year mathematics team as could be gathered anywhere. This team stood up well in the contest which was close at all times. Hyde Park showed remarkable staying powers, holding itself down to steady, consistent work even after disheartening announcements. The Hyde Park team finally won the contest, two to one. The judges graded independently throughout and submitted score cards showing details that agreed substantially throughout in spite of the fact that the contest was exceedingly close—in fact the scores were actually reversed near the close of the contest. The decision was as decisive as in a 100-yard dash.

The mathematics faculties agree that the experiment was of great educational significance. Agreements have been reached whereby the two schools will have an annual mathematics "meet" in the future, extending throughout the four years of high school mathematics. A valuable cup has been donated and will be the object for competition, for several years. Some of the technique has been revised slightly and interest will be accelerated.

The experiment is a definite suggestion for other departments. It seems to be entirely possible to have contests in Latin, history, mathematics or even general inter-class contests with as much enthusiasm and profit as an athletic contest. An enthusiastic teacher of arithmetic would certainly find it profitable if he were to take a team to some neighboring grade building and let them "scrimmage" against the team of one of his mathematics friends. The old-time "spelling bees" certainly were a powerful stimulus and there seems to be no reason why the same idea cannot carry over to other academic studies.

No doubt there are objections to the scheme, especially if it is not carefully directed. But in this it is like an athletic contest. Its value will depend, as every school activity does, on the

degree and quality of faculty direction. A hearty spirit of co-operation on the part of the two faculties will insure success to the larger issues involved.

Real Significance of Contest.

The writer does not wish to exaggerate its significance. It is simply a unique device which may upon experimentation prove to be of assistance in the solution of the problem of individual differences inasmuch as it will be a powerful stimulus to the enthusiasm and effort of the "A" student in mathematics. There is considerable evidence that teachers of mathematics are putting forth serious effort to solve the problem of individual differences. Recent programs are characterized by discussions of supervised study, standard tests, and devices for teaching pupils how to study. But these topics are directed to help the slow worker. It is in accord with our American ideals that our first efforts should be directed towards helping the slow worker. But the fast worker is entitled to consideration. It is necessary that a definite technique be developed to direct in the most efficient way the enthusiasm and energy of the fast worker in mathematics. Mathematics exhibits built up by students (see the article by Reeve in *School and Society,* August 7, 1915), mathematics clubs, and proper library direction of supplementary reading are designed with the same purpose. The mathematics contest may constitute a part of this larger technique that needs to be developed. For a more complete discussion of the relation of the contest to the general problem of individual differences, the reader is referred to a series of articles by the author beginning in the October number of the *School Review.*

BULLETIN 1915, NO. 35.

The United States Bureau of Education has just issued Bulletin 1915, No. 35, on *Mathematics in the Lower and Middle Commercial and Industrial Schools of Various Countries Represented in the International Commission on the Teaching of Mathematics.*

This bulletin has been prepared by Dr. E. H. Taylor, with the editorial co-operation of the members of the Commission in the United States. It is a bulletin of ninety-six pages, and will be furnished to teachers of mathematics upon application to the United States Bureau of Education at Washington.

THE PROOFS OF THE LAW OF TANGENTS.

By R. M. Mathews,
Riverside, California.

In the triangle ABC let α, β, γ be the angles at the respective vertices and a, b, c the sides opposite. The title "law of tangents" is used to denote the trigonometric formula

$$\frac{a-b}{a+b}=\frac{\tan \frac{1}{2}(\alpha-\beta)}{\tan \frac{1}{2}(\alpha+\beta)},$$

and each of those formed by cyclic permutation of the letters.

The proofs of this theorem in American textbooks stand in decided contrast to those of the law of sines and law of cosines. The proofs of these are based directly on the triangle and are such as to suggest the one needed extension in definition; when α is an obtuse angle.

$$\sin \alpha = \sin(180°-\alpha), \cos \alpha = -\cos(180°-\alpha).$$

These two definitions, be it observed, require no notion of co-ordinates or of quadrants. On the other hand, in ten of a group of twelve American texts, the only proof of the law of tangents is by algebraic manipulation from the law of sines and involving the factor formulas for the sum and difference of two sines. The proofs of these two formulas, being based on the addition formulas, are invariably preceded by the definition of the functions for the general angle, reduction to the first quadrant, and proof of the regular list of trigonometric identities. Thus the attainment of a formula that applies to triangles only seems to depend on much formal development of general and analytic trigonometry.

The law of tangents can be proved directly from a figure, however. Such proofs are contained in the other two of the dozen American books examined and in every one of four foreign texts that were at hand. Altogether there seemed to be eight different proofs but when reduced to uniform notation and drawings, it was discovered that there are three essentially different types according to the auxiliary lines. We may start at C as center and draw a circle with (1) a as radius, or (2) b as radius. Or we may start by bisecting γ or its exterior angle. In the first two cases the object is to make $(a+b)$ and $(a-b)$ and find $\frac{1}{2}(\alpha+\beta)$ and $\frac{1}{2}(\alpha-\beta)$. The procedures are parallel. In the other case we make $\frac{1}{2}(\alpha+\beta)$, as complement of $\frac{1}{2}\gamma$, and find the other quantities. In each of the following proofs we take $a>b$.

1. With a radius a, a semicircle is described about C as center

cutting b extended at D and E (Figure 1). Draw BE, BD, and then DF parallel to BE cutting BA at F. Now the essential facts are

$$a-b = AD \quad \angle BDA = \tfrac{1}{2}(\alpha+\beta)$$
$$a+b = AE \quad \angle DBF = \tfrac{1}{2}(\alpha-\beta)$$
$$\angle ABE = 90^\circ - \tfrac{1}{2}(\alpha-\beta)$$
$$\angle AEB = \tfrac{1}{2}\gamma = 90^\circ - \tfrac{1}{2}(\alpha+\beta)$$
$$\angle EBD = \text{rt.} \angle = \angle BDF.$$

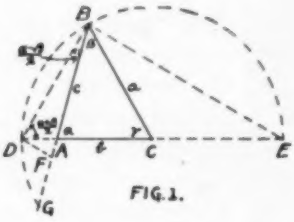


FIG. 1.

These relations of the angles can be established in a variety of ways, as inspection of the figure will show. This constitutes one of the sources of variation in the proofs. We note that if BA cuts the circle again at G, the central angle GCD is a useful auxiliary.

To use these relations there are two different procedures.

First, in rt.$\triangle$'s DFB and BDE

$$\frac{\tan \frac{1}{2}(\alpha-\beta)}{\tan \frac{1}{2}(\alpha+\beta)} = \frac{DF}{DB} \Big/ \frac{BE}{DB} = \frac{DF}{BE},$$

and

$$\frac{DF}{BE} = \frac{a-b}{a+b},$$

because of similar triangles.

On the other hand, apply the law of sines to the triangles ABD and ABE:

$$\frac{a-b}{c} = \frac{\sin \frac{1}{2}(\alpha-\beta)}{\sin \frac{1}{2}(\alpha+\beta)}, \quad \frac{a+b}{c} = \frac{\sin[90-\frac{1}{2}(\alpha-\beta)]}{\sin \frac{1}{2}\gamma}$$

$$\therefore \frac{a-b}{a+b} = \frac{\sin \frac{1}{2}(\alpha-\beta)}{\sin \frac{1}{2}(\alpha+\beta)} : \frac{\cos \frac{1}{2}(\alpha+\beta)}{\cos \frac{1}{2}(\alpha-\beta)},$$

whence the theorem.

2. With a radius b a semicircle is described about C as center cutting a at D and its extension at E. (Figure 2). Draw AE,

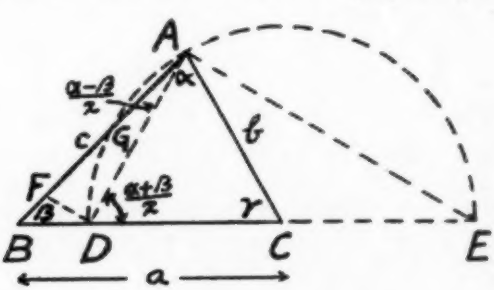


FIG. 2.

AD and then DF parallel to AE. Here the essential facts are:

$$a-b = \text{BD} \quad \angle\text{DAC} = \tfrac{1}{2}(\alpha+\beta) \quad \angle\text{BAE} = 90^\circ + \tfrac{1}{2}(\alpha-\beta)$$
$$a+b = \text{BE} \quad \angle\text{BAD} = \tfrac{1}{2}(\alpha-\beta) \quad \angle\text{BEA} = \tfrac{1}{2}\gamma = 90^\circ - \tfrac{1}{2}(\alpha+\beta)$$
$$\angle\text{DAE} = \text{rt.} \angle = \angle\text{ADF}.$$

As before, there are several ways to establish these facts, whence come differences in proofs. If AB cuts the semicircle at G, the central angle GCB is a useful auxiliary.

The final steps in the proof may proceed either by using right triangles ADF and ADE to write $\tan\frac{1}{2}(\alpha-\beta)$ and $\tan\frac{1}{2}(\alpha+\beta)$, or by applying the law of sines to the triangles ABD and ABE.

3. (1). To the bisector of γ drop perpendiculars AD and BE (Figure 3). Draw AH parallel to the bisector and cutting BE at H. Let $\theta = \angle\text{ABH}$. Then

$$\begin{aligned}\theta+\beta+\tfrac{1}{2}\gamma &= 90^\circ \\ &= \tfrac{1}{2}\alpha+\tfrac{1}{2}\beta+\tfrac{1}{2}\gamma. \\ \therefore \theta &= \tfrac{1}{2}(\alpha-\beta).\end{aligned}$$

$$\tan\tfrac{1}{2}(\alpha-\beta) = \frac{\text{AH}}{\text{HB}} = \frac{\text{EC}-\text{DC}}{\text{BE}+\text{AD}} = \frac{(a-b)\cos\frac{1}{2}\gamma}{(a+b)\sin\frac{1}{2}\gamma}.$$

$$\therefore \tan\tfrac{1}{2}(\alpha-\beta) = \frac{a-b}{a+b}\cdot\cot\tfrac{1}{2}\gamma = \frac{a-b}{a+b}\tan\tfrac{1}{2}(\alpha+\beta).$$

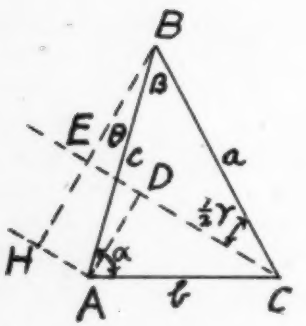


FIG. 3.

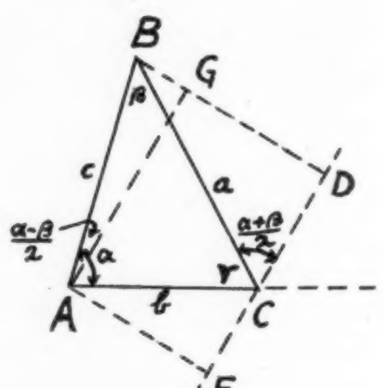


FIG. 4.

This proof is essentially the same as given in Hall and Frink, *Trigonometry*, p. 54, and Wilczynski, *Plane Trigonometry*, p. 105, Ex. 2.

(2). The following proof, suggested by the foregoing, I have not found in print.

Bisect the exterior angle of γ by FCD on which the perpen-

diculars AF and BD are dropped (Figure 4). Draw AG parallel to DF cutting BD at G. Now

$$\angle \mathrm{DCA} = \tfrac{1}{2}(\alpha+\beta), \quad \angle \mathrm{GAB} = \alpha - \tfrac{1}{2}(\alpha+\beta) = \tfrac{1}{2}(\alpha-\beta).$$

$$\tan \tfrac{1}{2}(\alpha-\beta) = \frac{\mathrm{BG}}{\mathrm{GA}} = \frac{\mathrm{BD}-\mathrm{AF}}{\mathrm{DC}+\mathrm{CF}} = \frac{(a-b)\sin \frac{1}{2}(\alpha+\beta)}{(a+b)\cos \frac{1}{2}(\alpha+\beta)}.$$

$$\tan \tfrac{1}{2}(\alpha-\beta) = \frac{a-b}{a+b} \tan \tfrac{1}{2}(\alpha+\beta).$$

(3). Draw the circumscribed circle to the triangle (Figure 5) and let the bisector of γ cut the circle at D. Draw DA, DB, and DF and DL perpendicular to CB and AB, respectively. On CB take CE = CA. Then DE = DA = DB, and

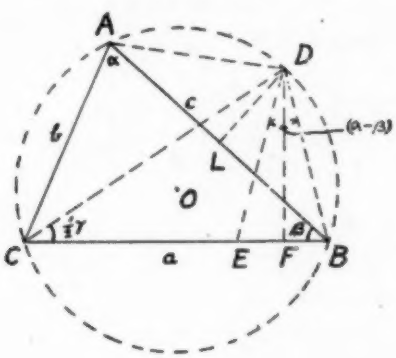


FIG. 5.

$$\mathrm{FB} = \tfrac{1}{2}(a-b) \quad \angle \mathrm{FDB} = \tfrac{1}{2}(\alpha-\beta)$$
$$\mathrm{FC} = \tfrac{1}{2}(a+b) \quad \angle \mathrm{CDF} = 90 - \tfrac{1}{2}\gamma = \tfrac{1}{2}(\alpha+\beta).$$

$$\text{Therefore } \frac{\tan \frac{1}{2}(\alpha-\beta)}{\tan \frac{1}{2}(\alpha+\beta)} = \frac{\mathrm{FB}}{\mathrm{DF}} \Big/ \frac{\mathrm{CF}}{\mathrm{DF}} = \frac{\mathrm{FB}}{\mathrm{CF}} = \frac{a-b}{a+b}.$$

This figure is of importance in that it is all ready to give the proofs of the formulas

$$\frac{a+b}{c} = \frac{\cos \frac{1}{2}(\alpha-\beta)}{\sin \frac{1}{2}\gamma}, \qquad \frac{a-b}{c} = \frac{\sin \frac{1}{2}(\alpha-\beta)}{\sin \frac{1}{2}\gamma},$$

$$a+b = 4\mathrm{R} \cos \tfrac{1}{2}(\alpha-\beta) \cos \tfrac{1}{2}\gamma,$$
$$a-b = 4\mathrm{R} \sin \tfrac{1}{2}(\alpha-\beta) \sin \tfrac{1}{2}\gamma,$$

where R is the radius of the circumscribed circle.

By using one of these direct proofs and the well-known direct proof for the formulas for the tangents of the half angles, the logarithmic solution of oblique triangles may be treated before passing on to the generalizations of analytic trigonometry.

THE HATCHET PLANIMETER.

By Herbert E. Cobb,
Lewis Institute, Chicago.

A hatchet planimeter for finding the area of an irregular figure is so easily constructed and readily used that it might well be brought to the attention of geometry pupils. Only a file and a hammer are needed in making this instrument. Take a piece of wire about an eighth of an inch in diameter and file one end to a point. Flatten out the other end and file it to a knife-edge, making the edge curved. At about an inch and a half from each end, bend the wire at right angles so that the knife-edge and the pointed end will lie on the same straight line. A piece of sheet lead may be rolled around the wire just above the knife-edge and hammered on so that it will not slip. This weight makes the planimeter easier to handle. Make the distance from the point to the center of the knife-edge, 10 cm., 4 in., or any convenient length.

To find the area: Draw a straight line through the center of gravity of the figure. To determine the center of gravity, cut the figure out of cardboard and balance twice on the edge of a knife blade. Place the point on the center of gravity and the knife-edge on the straight line. Move the point along the line to the boundary and around the boundary back to the center of gravity, and measure the distance of the knife-edge from the straight line. The product of this distance by the distance from the pointed end to the center of the knife-edge is the area. The accuracy of the result is tested easily on squared paper by finding the area of squares of various sizes.

A SIMPLE AND EFFECTIVE METHOD OF SOLVING A POLYNOMIAL.

By C. H. Forsyth,
University of Michigan, Ann Arbor.

The purpose of this paper is to demonstrate a simple and effective method of determining the values of the real roots of any polynomial.

Anyone familiar at all with the general problem under discussion is acquainted with the various helps in locating the real roots of any polynomial. Furthermore, supposing a root lies

between r and $r+1$, it is well known that if the given equation (say, in x) and the successive quotients are divided by $x-r$, the corresponding remainders will form the coefficients of a new equation whose roots will differ from those of the original equation only in that they are diminished by r. Hence, in the new equation the root under investigation lies between 0 and 1. So let us assume that our root is not only located but located between 0 and 1.

At this point, several methods are available, such as Horner's, Newton's, or direct substitution of trial values through the use of a table of powers of integers, together with a final interpolation; but we believe the following simple method will be found particularly practical in that it makes no use of an extensive knowledge of the theory of equations or of the calculus and is at the same time just as effective.

Suppose the polynomial involves the single variable x, then (1) neglect powers of x above the first and solve the corresponding linear equation for x; (2) neglect powers of x above the second, and substitute the value just found for one of the x's in x^2 and again solve the equation of the first degree in x; (3) neglect powers of x above the third and substitute value just found for two of the x's in x^3 and one of the x's in x^2, and again solve an equation of the first degree in x; and so on. Each time we take one more power of x and solve an equation of the first degree.

Oftentimes it saves time and labor to leave out some of the steps mentioned above. Thus, after estimating the first decimal place of the root by solving the first linear equation, this value may be substituted at once in all the terms of the equation leaving, however, one x in each term within which it occurs. In any case, even after all the terms of the equation are in use, it will most always prove worth while to continue substituting the values just found until the value found is the same as the value substituted. Once the first decimal place is thus reproduced the solution of the corresponding linear equation should be extended to give the second and possibly the second and third decimal places. The process of substitution should then be continued again until the value substituted is reproduced in the solution.

It is suggested also that if the successive values found by the plan just suggested, for the first decimal place, prove to vacillate widely (as usually occurs), an average of two of such values wisely chosen will be found very close to the value to

be determined and a substitution of this average value will shorten the work.

As an example, let us determine the value of the root between 0 and 1 in

$$x^4+5x^3+8x^2+3x-3=0.$$

The first approximations are 1, .27, .54, .33 and .48 and we might continue on thus, but an average of the last two or .41 will reproduce itself; and so we immediately solve for the next decimal place and obtain .417. The next approximation is .412 and an average of these two values or .414 will reproduce itself; and so on to as many decimal places as are needed.

GRAPHICAL METHOD FOR CUBIC EQUATIONS.

By Alfred Ritter,

New York City.

In the May issue of this magazine, there appeared a description of a graphical method for solving quadratic equations. A similar scheme may be worked out for cubic equations.

The general cubic equation may be reduced to the form

$$x^3+ax^2+bx+c=o,$$

or $$x^2+ax+b=-\frac{c}{x}.$$

If y be substituted for either member of this equation,

$$y=x^2+ax+b \quad \text{(equation of a parabola).}$$

$$y'=-\frac{c}{x} \text{(equation of a hyperbola).}$$

We have $y=y'$, therefore the intersections of the parabola with the hyperbola give the roots of our equation.

To solve the problem practically, draw a series of hyperbolas which have the equation $xy=-c$, c representing the parameter (see Figure 1).

On transparent paper draw a parabola having the equation $x^2=y$. If this parabola is placed upon the series of hyperbolas in such a way that its symmetric axis lies parallel to the y-axis, and intersects the x-axis at $x=-\frac{a}{2}$, also in such a manner that the parabola itself intersects the y-axis at $y=+b$, then the parabola has the equation,

$$y=x^2+ax+b.$$

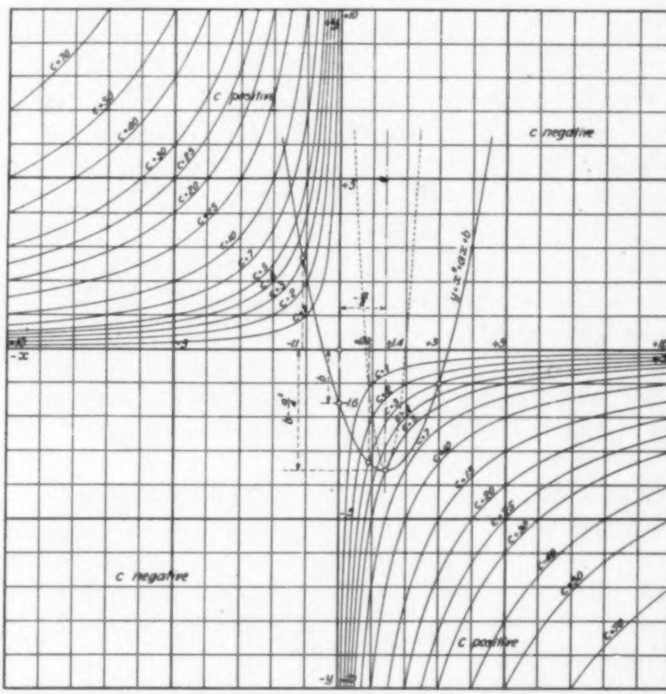
Instead of letting the parabola intersect the y-axis at $y=b$, the ordinate $y=b-\frac{a^2}{4}$ may be given to the vertex of the parabola.

The intersecting points of the parabola with the hyperbola (with the given value of c) give the desired roots.

Example:

$$\text{Solve } x^3-2.\ 8x^2-1.\ 6x+3=0.$$

We have $-\frac{c}{2}=+\ 1.4$; $b=-1.6$; $c+3$.



In Figure 1 we find the three roots $x=+0.9$; $x=+3$; $x=-1.1$.

If the value of c is negative rotate the series of hyperbolas 90°, instead of drawing them again in the remaining quadrants. The method shows at a glance whether the equation has 3,1, or no real roots.

If one of the values of a, b, or c is so large that it is no longer on the diagram, we need only to consider the figures on the axis as multiplied by 10, and the values of c by 100 (or, if necessary, by 100 and 10,000, respectively). The parabola changes accordingly, as shown by the dotted curve in Figure 1.

HISTORICAL NOTES IN TEXTBOOKS ON SECONDARY MATHEMATICS.

By Professor G. A. Miller,
University of Illinois, Urbana, Ill.

It is well known that some of the historical notes in the textbooks on secondary mathematics are inexact. Recently there has appeared a fourth edition of an important book entitled, *First-Year Mathematics for Secondary Schools,* by Ernst R. Breslich, University High School, The University of Chicago. This book contains a considerable number of interesting historical notes, which will doubtless be read with care, not only by the students who may be using this book but also by those who are interested in preparing textbooks of a similar grade. Hence it may be important to direct attention to a few instances where these notes are stated in such a manner that they are likely to give rise to incorrect impressions.

In the biographical sketch of Descartes, which precedes the title page of the book under consideration, there appears the statement that he "gave the rule for finding the number of positive and the number of negative roots of an equation, and this is still called Descartes' Rule." As is well known Descartes' Rule does not always enable us to find the actual number of the real roots of an equation. Such a simple equation as

$$x^2-x+1=0$$

cannot have more than two positive roots according to Descartes' Rule, but, as a matter of fact, it has no positive root. It was Charles Sturm, who gave, in 1829, the first general rule to determine the exact number of the real roots between two real numbers, of a numerical algebraic equation in one unknown with real coefficients.[1]

In the given biographical sketch there appears also the statement that he "introduced the system of indices now used in mathematics." The term index is used with various meanings in the mathematical literature. For instance, we frequently speak of the indices which appear as subscripts, such as

$$x_1, x_2, \quad . \quad . \quad . \quad . \quad , x_n.$$

In 1649 F. van Schooten made an approach towards such a system of notation in his Latin edition of Descartes, by using such symbols as ${}_2C$, ${}_3C$. In Newton's *Principia* similar symbols appear frequently in the modern form C_2, C_3, etc. This common system of indices is certainly not due to Descartes.[2]

[1]Cf. Bocher, *Bulletin of the American Mathematical Society,* Vol. 18 (1912), p. 1.

It is probable that the system of indices to which the given quotation relates is our present system of notation for exponents. In this connection it may be said that Descartes never used the general notation a^n, where n is any natural number, although he used, in the modern form, such symbols as a^2, a^3, a^4, . . ., "etc., to infinity" for given positive integral powers of a. The use of a general exponent, representing any real or complex number, came after the days of Descartes. While we do not want to imply that brief historical notes can always be so stated as to exhibit the actual state of affairs exactly, yet it seems that the statement that Descartes "introduced the system of indices now used in mathematics" could be improved by replacing the word "indices" by the word exponents.[3]

Various other statements in this brief biographical sketch of Descartes would convey more accurate information if there had been room to add the desirable explanations. In particular, the statement that he "realized the true meaning of negative numbers and used them freely" would appear in a new light if it could have been added that Descartes never employed the terms *positive* and *negative* as regards numbers; for negative number he still used the term false number *(nombre faux)*, and when he spoke of false numbers he gave only their absolute values and viewed them as increasing with their absolute values.[4] Like Stifel and Girard had done earlier, he considered negative numbers as less than nothing.

The little biographical sketch of Tartaglia, which appears near the middle of the book under consideration, is headed *Niccolo Fontana.* It should be noted that we do not know that the real name of Tartaglia was Fontana. This question was considered by G. Eneström in the *Bibliotheca Mathematica,* Volume 4 (1903), page 87. By an oversight the large French mathematical encyclopedia contains the statement that the real name of Tartaglia was Fontana, but this statement is corrected on page 9 of the *Tribune Publique,* issued in connection with this encyclopedia.

In the biographical sketch of Tartaglia, it is said that he is best known today on account of "his discovery of the solution of the cubic equation, about 1530." In *Pascal's Repertorium der höheren Mathematik,* Volume 1 (1910), page 282, there appears the following statement: "The first solution of the cubic equa-

[2]Cf. Wieleitner, *Geschichte der Mathematik,* 1911, p. 4.
[3]Exponents were represented by Roman number symbols at a little earlier date by J. Hume.

tion is due to Scipione del Ferro." In Volume 7 of the *Bibliotheca Mathematica,* page 38, G. Eneström considers the question whether Tartaglia really discovered his solution of the cubic equation or obtained it from the earlier work of Ferro. Although it seems impossible to answer this question at present, yet there seems to be no good reason to regard Tartaglia as the one who first discovered an algebraic solution of the cubic equation.

These few observations as regards the historical notes in question are intended to convey additional information on the matters considered, rather than to correct inaccuracies. While it is a very difficult matter to write brief historical notes which do not either overrate or underrate the value of the particular work in question, yet such notes should be encouraged since they often provide an easy means to make a first approximation towards the true situation. Moreover, they tend to direct attention to the fact that mathematics *grew* to its present size through the efforts of men who possessed various degrees of light, and that the intellectual weakness as well as the intellectual strength of these men is often reflected in the mathematical literature.

The present writer regrets that the historical notes in the textbooks on secondary mathematics so seldom include any relating to present mathematical activities. The latter notes would tend to direct still more attention to the fact that mathematics is a living subject, which has grown in the past and is growing still more rapidly at the present time. The dynamic element of mathematics would thus appear in a stronger light and would tend to enthuse where the static elements often fail to make an impression.

A great advantage of notes relating to modern mathematical activity is that the accuracy of such notes can usually be much more easily established than that of notes relating to ancient and medieval mathematics. In the opening article of Volume 14, 1914, of the *Bibliotheca Mathematica,* G. Eneström considers the difficulties in the way of introducing extensive historical notes into the schoolbooks on mathematics. He refers to the fact that several years ago, when new regulations were adopted in Sweden in regard to the secondary schools, it was at first proposed to recommend especially that historical information be combined with mathematical instruction. This plan was abandoned because it was thought that the Swedish teachers of secondary mathe-

[4]*Encyclopédie des Sciences Mathématiques,* Tome 1, Vol. 1, p. 35.

matics would probably not secure sufficiently accurate information along historical lines, and that it would be better not to refer to historical matters than to impart inaccuracies.

In the textbook under consideration, there appear thirteen biographical sketches. None of the subjects of these sketches lived as late as the end of the first quarter of the nineteenth century. Our study of the history of mathematics often seems to exhibit a veneration of the past akin to that ascribed to the ancient Chinese. Even elementary mathematics has been greatly advanced in recent times, and it is easy to secure accurate information as regards some of these advances. Moreover, references to modern mathematical activities tend to give a more correct outlook on the modern intellectual life.

STORIES.

Asked of a class beginning physics: "What is meant by the weight of a body?"

Answer: "Weight is that property of a body by virtue of which it has heft."

Given by a girl in the junior class as an illustration of the fact that heat expands and cold contracts: "On a cold night in winter the stove covers sometimes contract so much as to fall inside the stove through the openings beneath."

Stated in all seriousness by a state official in a public address on "The Teaching of Elementary Science":

"The cold air passing through the furnace is heated, becomes lighter, rises, and *leaves a space behind it* into which the outside air rushes through the cold-air box."

All are familiar with the little girl who defined the equator as "a menagerie lion," but here is Dorothy, who has views about the equator also.

Teacher—"Dorothy, what is the equator?"

Dorothy—"An imaginary line, ma'am, around the earth midway between the poles."

Teacher—"Could you hang clothes on that line?"

Dorothy—"Yes, ma'am."

Teacher—"What sort of clothes?"

Dorothy—"Imaginary clothes, ma'am."

Teacher—"Under what conditions will a body float?"

Pupil—"When it has been in the water three days."

Teacher—"What follows if the three sides of a triangle are equal to each other?"

Pupil—"The other side will be equal, also."

REPORT OF CHEMISTRY SURVEY.

By S. R. Powers,
Garfield High School, Terre Haute, Ind.

This report is the result of a questionnaire survey. The questionnaire asked for the conditions under which the high school chemistry teacher works, his training for his position, his method of teaching the subject, and his opinion of the values derived from the chemistry course. One thousand thirty-seven blanks were sent out and one hundred fifty-four replies were received. Seven hundred sixty were sent to states belonging to the territory covered by the Central Association of Science and Mathematics Teachers. The remaining three hundred were sent to all parts of the United States except New England.

The numbering in this report corresponds with the numbering in the questionnaire blank, which is here given:

A. Time Allotment of Subject.

1. State number of periods given to laboratory work per week,....... First term,............; second term,............
2. State number of periods given to class recitation per week,......... Length of periods,...............
3. What is your weekly arrangement of your work?.................
4. Are you satisfied with this arrangement?......... Why?......... ....
5. Are you allowed time in the school day for care of apparatus and preparation of materials?......... How much?..................
6. In what year is chemistry taught?..............................
7. Is it required or optional?......................................
8. State briefly how the above conditions might be improved:......... ....

B. Equipment.

9. Do you have a well equipped laboratory?........................
10. Kind of location in building (floor, exposure, etc.):..............
11. How is the light?..
12. How is the ventilation?..
13. Do you have hoods?..... Do you have water and gas at table?.....
14. Does each student have an individual locker?....................
15. Approximately what number of students take chemistry?..........
16. What is your approximate school enrollment?....................
17. What is your approximate annual allowance for supplies?..........
18. What is the approximate value of your laboratory equipment?.....
19. Does the student pay for breakage?.............................
20. Does the student pay for material used?...... How much?......
21. How many volumes of books in your school chemistry library?..... Number of texts other than the adopted text?...... Number of books on special subjects?...... Name any periodicals you get for your school library:...
22. Name the library books you make most use of:...................

23. List any additional equipment that you particularly desire:........
24. Estimate the cost per term of conducting a course in chemistry for a class of sixteen students:....................................

C. Training of Teacher.

25. State length of your training in each kind of school, name of school, and degrees taken:

	Name of School.	No. of Months.	Degree.
High School			
College or Normal......			
University			
Graduate Work			

26. What is your major subject?........ What other science courses have you had?..
27. What proportion of your study has been devoted to subject matter and what to method of teaching?................................
28. To what teachers' organization do you belong?................. Do you usually attend their meetings?..........................
29. How many years have you taught chemistry?....................
30. What have you published?..

D. Service.

31. How many classes in chemistry do you have?..................... How many students are there in each class?...................... What other classes do you have?..................................
32. What school activities do you have charge of?.................. What is the average number of hours devoted to this per week?....
33. Do you have a paid student assistant?......... Do you have any student assistant? ....
34. About how many hours per week do you devote to library study in preparation for your work?........ How many hours to preparation of material for the laboratory?......... How many hours to cleaning up laboratory?...
35. Do you make an effort in the laboratory to train your students in neatness and cleanliness?......... What means do you use?......
36. Do you take field and industrial trips with your students?......... Approximately how many per year?.............................

E. Method in Teaching.

37. Do you make your first approach to a topic in the laboratory, or by textbook work and class recitation?............................ Why? ....
38. To which do you give greater emphasis, textbook work or laboratory work? ....
39. What text do you use?............... Manual?............... Do you draw material from more than one manual?...............
40. Do you write your own laboratory directions?.................... Why? ....
41. About how many pages of text do you cover during the first half year?........... During second half year?...........
42. Summarize your plan for the student's record of experiments:
a. When are results recorded?..................................
b. What form of record do you have your students follow?......

c. Do you have a printed outline to aid your student in writing notes? ....
By whom prepared?..
d. What is your method of correcting notebooks?................

43. Do your students take time outside of the laboratory period to write up any discussion or explanation of work done in laboratory?...... Approximately how much per week?............................

44. Do you find correcting notebooks burdensome?........ About how much time does it require per week?..............................

45. Do you use loose leaf or bound notebooks?.................... Why? ....

46. In many laboratory manuals each exercise is set off as a unit within itself. Is this a good plan or would you think it advisable that some effort be made to show the connecting link between two given exercises and thus insure a more definite continuity?

47. About how much laboratory time do you give to individual instruction and conference with students?.............................

48. About what per cent of the class recitation time is devoted to discussion or quiz on laboratory work?...........................

49. Do you make any other provisions for discussion of the laboratory work? ....
How about the weak student?......................................

50. Do you find the lecture demonstration a success?.................

51. Do you "give lectures" on chemistry to classes?......... Is this method a success?..

52. Do you direct the use of library books on chemistry?............ In what way? ....

53. In the study of any element, say chlorine, by what exercise or by what means do you introduce the student to a first-hand knowledge of the element?..
Is this your usual method?...

54. Do all students work on the same experiment at the same time? .... If so, how do you keep them together?.................

55. How many exercises can you successfully direct at one time?......

56. Do you find differences in student ability due to sex?......... If so, state them: ....
Have you any definite evidence of this?...........................

57. Do you encourage students to study problems involving chemistry that is of special interest to them? ..... If so, to what extent?.....

58. Do you place much emphasis on drawing of laboratory apparatus used in a given exercise?......... Why?.......................

F. Content of Course.

59. About what per cent of the total number of your laboratory exercises are quantitative? ....

60. Give per cent of second half year devoted to study of organic subjects.........; to metals.........; to nonmetals.........; to general principles.........

61. Is organic chemistry considered too much or too little in the average text of today?..

62. Are the metals given too much attention?..........................
Is the metallurgy of the common metals given too much attention?

63. The molecular theory?..

64. The atomic theory?..
65. Should the periodic law be considered in first year chemistry?......
Why? ....
66. Do you make special effort to teach the application of chemistry? .... Do you make any effort?......... Do you teach theory or application first?..
67. Should courses be provided to teach only the application of chemistry to domestic science and agriculture?........................
68. What use do you make of the exercises published in SCHOOL SCIENCE AND MATHEMATICS under *Live Chemistry*?.......................

G. VALUES DERIVED FROM CHEMISTRY.

69. In your opinion is chemistry of greater value to your community from a practical standpoint or from a cultural standpoint?........

Note: By practical value we mean a value which is of economic importance to the community: by cultural value we mean a value which is of importance to the individual in making him more appreciative of life, its pleasures, and its disappointments.
Have you any evidence or experience that will substantiate your opinion? ....

70. What are the important attributes which laboratory work in chemistry should contribute to the students' education? Arrange in order of importance: ....
71. Do you attempt to cultivate the attitude which we call "power of analysis" or "scientific attitude of mind"?.......................
Do you emphasize this as an ideal applicable to all life's problems or as an attitude to be made use of in connection with problems in chemistry only? ....
72. Is this scientific attitude of mind of greater or less importance than knowledge of subject matter?...................................
73. Do you give much attention to college entrance requirements?.....
74. Upon what basis do you make out your term grade in chemistry? Is the same basis uniformly used in other departments in your school? ....

H. GENERAL.

75. What science courses are required for graduation in your school?
....
76. In what order are they usually taken?.............................
....
Would you recommend another order?........ If so, what?........
Do you think any chemistry should be included in first year general science?......... If so, what topics?.............................
77. About what average per cent of your students make grade A?......
B?...... C?...... Fail?...
Do you base these figures on actual average or on estimates?......

1. Twelve have two laboratory periods per week, four have either two or three, eight have three, ninety-eight have four (two double periods), six have five, and five allow a different number, first and second term.

2. Ten have two recitation periods per week, one hundred fourteen have three, thirteen have four, six have five, three have periods less than forty minutes, forty-seven have forty, seventy-four have forty-five, five have fifty, and four have 60-minute periods.

3. Seventy have class and laboratory on alternate days, fifty-nine use consecutive days, and eight have no regular order. At least twenty-two have daily double periods.

4. One hundred and three are satisfied, thirty are not.

5. Ninety-three are allowed some school time for care of apparatus and materials, fifty-eight are not.

6. Forty-seven teach chemistry third year, fifty-five fourth year, and forty-nine in either third or fourth year.

7. Chemistry is required in twelve schools, optional with other science course or courses in fifty-three, purely elective in forty-eight, and required in some courses only, in thirty-eight.

8. ....

9. One hundred and four have well equipped laboratories, thirty-one have fair equipment and ten poor.

10. Twenty-five schools have chemistry in basement, twenty-two on first floor, ninety-two on upper floors, and one in attic.

11. One hundred and seventeen have good light, eighteen fair, and seventeen have poor.

12. Eighty-seven have good ventilation, thirty-seven have fair, and twenty-eight have poor.

13. One hundred and twenty-two have hoods of some sort, thirty-two have none. One hundred and thirty-three have water and gas at tables, eight have neither, one has gas only, and three have water only.

14. One hundred and thirty-three schools provide individual lockers.

15 and 16. In seven schools, twenty-five per cent of enrollment take chemistry; seven, twenty to twenty-four percent; twenty, fifteen to nineteen per cent; seventeen, twelve to fourteen per cent; thirty, nine to eleven per cent; fifty-one, five to eight per cent; ten, three to four per cent; one, one and one-half per cent.

17. The figures show that in one school the cost per year per student, based upon number of students taking chemistry, and annual allowance for supplies is $20; in one, $15; in one, $12; in three, $10; in five, $6-$9; in six, less than $0.90. Omitting these figures, the average cost per pupil is $2.90.

18. ....

19. One hundred and sixteen require students to pay for breakage, thirty-one do not.

20. Twenty-one, either by laboratory fee, or otherwise, require some payment for material used.

21. Forty-three have fair libraries, eighty-three have small libraries, eighteen have none.

22. Reference books used in order of their popularity are Thorp's *Industrial,* A. Smith's *General,* Kahlenberg's *Chemistries,* Newth's *Inorganic,* Duncan's *Chemistry of Commerce,* Leach's *Food Inspection and Analysis,* Bailey's *Sanitary and Applied Chemistry,* Lassar-Cohn's *Chemistry in Daily Life, Remsen, Roscoe and Schorlemmer, Rogers and Aubert,* Wiley's *Pure Foods, Newell, Snell,* Duncan's *Chemical Problems,* Bird's *Wonders of Science in Modern Life, McPhearson and Henderson, Brownlee,* Lewis B. Allyn's *Elementary Applied Chemistry,* Olsen's *Pure Foods.* A number of other books were listed by only one teacher.

23. ....

24. ....

25. Ten teachers who replied are not college graduates, twenty-one are graduates of small colleges, twenty-two are graduates of universities, sixty-three have done graduate work, thirty-three have taken graduate degrees, and three have Ph. D. degree.

26. Ninety have chemistry for major, twenty-four have physics, twenty have some other science, eight have mathematics, and seven have some other subject.

27. Ninety-five have devoted some time to study of methods of teaching.
28. One hundred and twenty-eight belong to teachers' organizations and one hundred eighteen usually attend.
29. Ninety-five have taught more than five years and fifty-six less than five years.
30. Thirty-one of the teachers who made replies have published something.
31. Forty-three have all of their time devoted to teaching chemistry. Forty-six have classes over twenty-four; ninety-six, less than twenty-four.
32. Ninety-one teachers have charge of some other school activities.
33. Nine have a paid student assistant, thirty-four have student assistant who is not paid, and 107 have no assistant.
34. Four devote no time to library study in preparation for their day's work; thirteen devote one hour per week; twenty-one, two hours; twenty, three hours; thirteen, four hours; twenty-seven, five hours; twenty-two, over five hours; two devote no time to preparation of materials; fifteen, one hour per week; twenty-eight, two hours; twenty-six, three hours; twenty, four hours; thirty-one, five hours or more. Five devote no time to cleaning up laboratory; twenty-four use one hour; thirty-nine, two hours; fourteen, three hours; four, four hours; eleven, five or more hours per week.
35. One hundred and forty-eight make effort to train in neatness, one does not. Four assess a fine of some sort and twenty deduct from grade for carelessness.
36. Nine take no trips; twenty-five take one trip; twenty-four, two trips; twenty-one, three trips; twelve, four trips; nine, five trips, and twenty take more than five.
37. Forty-nine make first approach to a new topic in laboratory, sixty-one by recitation, and thirty-nine vary. Twenty-one think some knowledge of material must precede laboratory work. Twelve think laboratory first encourages spirit of investigation. Nine think laboratory first is natural order. Three think class work incites curiosity for laboratory work. Sixteen think laboratory first makes text mean more. Four think text first is more convenient for teachers and works little loss to the pupil. Three say it depends on text. Nineteen say laboratory work is based on recitation. Nineteen use different method for different subjects. Four think with short periods new work cannot be begun in laboratory.
38. Thirty-four emphasize text more, fifty-seven laboratory more, and fifty-four about equal.
39. *Brownlee's* text is used in fifty-six schools; *McPhearson and Henderson* in thirty-six; *Snell,* three; *Morgan and Lyman,* eleven; *Remsen,* two; *Newell,* thirteen; *Kahlenberg and Hart,* three; several different texts, two; *Irwin-Tatlock,* one; *Blanchard and Wade,* one; *A. Smith,* eight; *Hessler and Smith,* twelve; *Peters,* one; *Bradbury,* two. Manuals: *Morgan and Lyman,* ten; *Brownlee,* forty-four; *McPhearson and Henderson,* twenty-four; *Newell,* eleven; *Tatlock,* one; *Minneapolis Sheets,* four; *Williams and Whitmen,* one; *Hessler and Smith,* eight; *Snell,* one; *A. Smith,* four; *L. B. Allyn,* one; *Williams,* one; *A. E. White,* one; *Peters,* two; *Bradbury,* two; *L. E. Knott,* one; *Heilman,* two; *Wade,* one; *Blanchard,* one. One hundred and two use more than one manual, twenty-eight do not.
40. Twenty-eight write their own directions, fifty-seven write part of them, and eighteen do not. Two use oral directions almost entirely.

Fifteen write own directions in order to apply work to local conditions. Twelve say no manual gives desired material entirely. Five say no manual suits individual ideas. Eighteen do not have time enough to write

laboratory directions. Eleven adapt work to material and apparatus of laboratory by writing own directions. Three write to make work more specific. Thirty-eight think available manuals are sufficient. Six modify manual to suit needs. Six write directions in special cases.

Note: Replies to thirty-nine and forty seem to indicate that many teachers, although having an adopted manual, draw material pretty largely from other manuals and write quite a number of their own directions.

41. Seventeen teachers cover less than 150 pages of the text during the first semester; thirty-three cover 150-175 pages; forty-four, 176-200 pages; twenty-nine, 200-225 pages; three, 225-250 pages, and three cover over 250 pages. During the second semester, ten cover less than 176 pages; sixty-three, 176-200 pages; seventeen, 201-225 pages; twenty, 226-250 pages, and one over 251 pages.

42. *a.* One hundred and thirty-seven teachers require part or all of laboratory record to be made in laboratory. *b.* Fifty-one have no set form for writing notes, ninety have some set form. *c.* Fifty-three use printed outline suggested by manual, twenty-nine have a printed outline prepared by self, ninety have no printed outline to aid students in writing notes. *d.* Five teachers read students' notes only occasionally after first few weeks. Twenty-two correct notes in laboratory with students as they are being written. Fifty-four simply mark errors and return notes to students for correction. Five read notes, check errors, and return to students for class consultation. Three read notes daily, check errors, and re-read at end of term.

43. Eighty-seven teachers require their students to take time outside of laboratory period for writing notes.

Note: Comparison with 42 *a* would seem to indicate that fifty teachers require all note writing to be done at time experiment is being performed.

In thirty-two schools the students use one hour per week outside of laboratory for writing notes; twenty use two hours; ten use three hours, and four use four hours.

44. Fifty-four teachers report that reading note-books is not burdensome. Eighteen use one hour per week; thirty-five, two hours; seventeen, three hours; eleven, four hours; thirteen, five hours; eight, six hours; two, seven hours; one, eight hours; seven, ten hours; one over ten hours.

45. One hundred and thirty-two teachers use loose leaf notebooks, fifteen use bound books, and two allow either.

Fifty-eight report that the loose leaf system is more convenient. Eighteen prefer it because spoiled sheets may be thrown away and new ones added. Sixteen report that they require notes on experiments to come in separately. Six think bound books are neater, more permanent, and train the student to think carefully before writing. Five think loose leaf system may be used to prevent students from copying from each other.

46. Forty-five prefer laboratory exercises to be definite units. Eighty-seven think some effort should be made in writing directions to show the connecting link between exercises.

47. Fifty-four teachers devote practically all of laboratory time to individual instruction and conference with student; twenty-eight use one-half of laboratory time for this work; two, one-third; eight, one-fourth; two, one-fifth; sixteen, little; three, two-thirds; three, three-fourths; two, none; eight, considerable; six, vary.

48. Thirty-three report that little of recitation time is devoted to laboratory quiz or discussion; seven report none; twenty-nine, ten per cent; twenty-six, twenty per cent; nineteen, thirty per cent; twelve, twenty-five per cent; one, forty per cent; seven, fifty per cent; three, sixty-six per cent; three, fifteen per cent; one, varies; one, all if necessary.

49. Eighty-four report that they make yet other provision for discussion of laboratory work, and forty-nine that they do not. One hundred and twenty-one make some provision for assisting the weak student.

50. Ninety-seven find the lecture demonstration a success, thirteen only in part, and thirty-five find it not a success.

51. Fifty-one make some use of lecture method, ninety-six do not. Forty report that they use it successfully.

Note: In all but two cases, the lecture method is used "occasionally," "briefly followed by quiz," etc.

52. One hundred and nine direct in some way the use of library books, twenty-three do not. Seventy-six simply give references for those interested. Eighteen give out topics to be worked up for class presentation. Two make special effort to work practical material. One appends a list of references to each laboratory exercise.

53. Seventeen begin the study of a new element by a study of its common compounds, sixty-eight by having student prepare element in laboratory, twenty-nine begin with demonstration and discussion, seventeen begin with a study of text.

54. Eighty-eight require all their students to work on same exercise at same time, sixty do not.

Twenty-five provide extra work for fast students in order to keep them together, thirty-seven require slow ones to do extra time, and ten use both methods.

55. Thirty-nine are able to direct only one exercise at a time; twenty-one, two; twenty-two, three; four, four; thirty-one, five or more.

56. Fifty-nine think there is a difference in chemical ability between the two sexes, eighty think there is not. Eighteen report that there is a difference in interest but not in ability. Twenty-eight report that girls are more painstaking but boys have better knack for laboratory work and show greater originality. Two think boys get mathematical part better. four think girls see deeper into the work than boys do.

57. One hundred and thirty-two teachers encourage students to study problems appealing to their own special interest. Twenty-six encourage laboratory work on the subject of interest and also assist them in their reading. Twenty-two encourage especially a study of local problems. Twenty-four assist students only as they take initiative. Eight present list of subjects to class for students to choose from for special study and require later report before class on work investigated. Three set off a part of time in regular chemistry course for a study of practical problems of interest to students.

58. Thirty-nine teachers emphasize drawing of laboratory apparatus, seventy-eight do not, and thirty-two place only small amount of emphasis upon it. Six think that drawing rivets attention to details. Fifty-nine think drawing is waste of time. Eleven think it encourages accuracy and neatness. Eleven think drawings are a matter of convenience to student in writing notes. Eighteen think drawing makes experiment mean more.

59. In sixty cases less than five per cent of the laboratory work is quantitative; in forty-seven cases, five to ten per cent; ten, eleven to fifteen per cent; ten, sixteen to twenty per cent; three, twenty-one to twenty-five per cent; two, twenty-six to thirty per cent; none, thirty-one to thirty-five per cent; one, thirty-six to forty per cent; two, forty-one to fifty per cent; four, all; five, none.

60. Fifty devote less than ten per cent of second half year to organic chemistry; twenty-nine, eleven to twenty per cent; eighteen, twenty-one to thirty per cent; ten, thirty-one to forty percent; one, forty-one to

fifty per cent; ten, none. Four devote less than ten per cent to metals; twelve, eleven to twenty per cent; twenty-one, twenty-one to thirty per cent; thirty-three, thirty-one to forty per cent; twenty-five, forty-one to fifty per cent; twenty-eight, fifty-one to sixty per cent; four, seventy-five per cent; three, eighty-five per cent; one, all. Seven devote less than ten per cent to non-metals; fourteen, eleven to twenty per cent; twelve, twenty-one to thirty per cent; twenty-six, thirty-one to forty per cent; six, forty-one to fifty per cent; one, fifty-one to sixty per cent; three, none. Thirty-four devote less than ten per cent to general principles; thirty-seven, eleven to twenty per cent; seventeen, twenty-one to thirty per cent; ten, thirty-one to forty per cent; one, forty-one to fifty per cent; three, none. One devotes twenty-five per cent to qualitative analysis, one uses L. B. Allyn's book.

61. Eighty-six think that organic chemistry receives too little attention in the average text of today; thirteen think too much, and twenty-nine think "about right."

62. Eighty-two think the metals are given too much attention, fifty-seven think not, and five think "about right." Fifty-three think metallurgy of common metals gets too much attention, and seventy-three think not, and five think "about right."

63. Twenty-seven think molecular theory is given too much attention, 102 think not, and three think "about right."

64. Thirty think the atomic theory gets too much attention, 104 think not, and four think "about right."

65. Ninety-two think periodic law should be considered and forty-one think not. Three think it should be taught because of its interest. Sixty-one think it unifies and classifies work. Twenty-three think it is too difficult. Two think it important and understandable. Nine think it does not have sufficient importance. One thinks the analytical classification better for high school students.

66. One hundred and thirty teachers make special effort to teach the applications of chemistry. Eighteen do only a little with this line of work. Eighty-seven present the theory first, thirty-one the application first, and thirty-two use varied methods.

67. Forty-six think courses should be provided to teach applications of chemistry to domestic science and agriculture, seventy think not.

68. Forty-three make considerable use of "Live Chemistry," fourteen make "little," forty-four, none, and seven read them.

69. Sixty think practical value of chemistry is first, sixty-four think cultural, and thirty-two think about equal.

70. ....

71. One hundred and twenty-eight try to cultivate "scientific attitude," nine do not. One hundred and seventeen make it applicable to all problems, eight just to chemistry.

72. One hundred and eight think this attitude is of greater importance than knowledge of subject matter, eleven think less, and twelve about equal.

73. Forty-three pay considerable attention to college entrance requirements; fourteen, just a little; and ninety-one, none.

74. Thirty-three make grade on basis of general ability and attitude. Thirty-one count recitation, laboratory, and quiz (and examinations) at one-third each. Nineteen count recitation, laboratory, tests, and final about equal. Three count recitation, 40; written work, 40; laboratory, 20. Nine count laboratory, 40; recitation, 40; and examinations, 20. There were also fifteen other methods used in making grades by one teacher each.

Fourteen have approximately same marking systems as other departments of the school, seventy-one have same, twenty-eight do not, and ten do not know system that is used by other departments.

75. In twenty schools one year of prescribed science is required for graduation, eleven require one prescribed science and one elective. One requires one prescribed and two electives.

In twenty schools two years of prescribed science are required for graduation. In one, two years of prescribed and one elective science are required.

In seven schools three years of prescribed science are required, and in six schools four years of prescribed science are required for graduation.

In sixteen schools no science is required. In twenty-eight schools one year of elective science is required, seven require two elective sciences and two require three elective sciences. Thirty schools have different requirements in different courses.

Thirteen teachers express their disapproval of a general science course.

76. In forty-nine schools physics precedes chemistry in the course of study and in forty-three schools chemistry precedes physics.

77. Thirty-one teachers report that less than five per cent of their students fail; thirty-one report five to seven per cent; forty-five, eight to ten per cent; and thirty-three, over eleven per cent. Five report no failures. In several cases the per cent of failure ran well up to twenty-five per cent.

TERRESTRIAL MAGNETISM.

The United States Coast and Geodetic Survey, Department of Commerce, has issued as Serial No. 3, Special Publication No. 25, a quarto pamphlet of 69 pages entitled *Results of Magnetic Observations made by the United States Coast and Geodetic Survey in 1914*, by D. L. Hazard.

This publication contains the results of magnetic observations made on land and at sea during the calendar year of 1914, together with descriptions of the stations occupied. Results are given for 385 stations in 289 localities, including an investigation of areas of marked local disturbance in Iowa and Minnesota. There is presented in tabular form a comparison of the declination results at 76 repeat stations with the results of earlier observations in the same localities. The results have been corrected to reduce them to the provisional international standard of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

The stations described are located in 33 states and territories, including Arizona, Alabama, Alaska, Arkansas, California, Colorado, Delaware, Florida, Georgia, Idaho, Illinois, Iowa, Louisiana, Maine, Massachusetts, Minnesota, Mississippi, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Texas, Vermont, Washington and Wisconsin.

Besides the scientific value of these observations, this work is of practical utility to engineers and surveyors, and particularly to those interested in retracing old property lines. In the early days and even more recently these lines were run with the compass almost exclusively and to return them a knowledge of the variation of the compass at the date of survey is essential.

The volume will be supplied without charge to persons interested by application to the Division of Publications, Department of Commerce.

PROBLEM DEPARTMENT.

By J. O. Hassler,
Englewood High School, Chicago.

Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and solutions will be credited to their authors. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.

Algebra.

436. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

Solve:

$$2xy = 32-4x+y. \qquad (1)$$
$$3yz = 94-y-6z. \qquad (2)$$
$$6zx = 81+3z-2x. \qquad (3)$$

I. *Solution by Mabel G. Burdick, Stapleton, N. Y.*

From (1) $\quad y=\dfrac{32-4x}{2x-1}.$

From (2) $\quad y=\dfrac{94-6z}{3z+1}.$

Equating and solving,

$$x=\frac{15z+21}{32}.$$

Substituting in (3),

$$9z^2+6z-255=0, \text{ whence } z=-17/3,\ 5.$$

Then x and y are found by substitution. The roots are: $x=-2, 3$; $y=-8, 4$; $z=-17/3, 5$.

II. *Solution by R. M. Mathews, Riverside, California.*

$$\text{Put } x=\frac{x'+1}{2},\ y=y'-2,\ z=\frac{z'-1}{3}.$$

Then

$$x'y'=30,$$
$$y'z'=96,$$
$$x'z'=80.$$

Whence $\quad (x'y'z')^2=6^2 8^2 10^2.$

and $\quad x'y'z'=\pm 480.$

If one is positive, all are positive; if one is negative, all are negative. Hence,

$$x'=5 \text{ or } -5,$$
$$y'=6 \text{ or } -6,$$
$$z'=16 \text{ or } -16.$$

Therefore (3, 4, 5) and (-2, -8, $-17/3$) are the finite solutions.

Geometry.

437. *Proposed by H. C. McMillan, Kingman, Kansas.*

Given two points on the same side of a straight line. Construct the maximum angle having its vertex on the given line and its sides passing through the given points.

I. *Solution by Norman Anning, Clayburn, B. C.*

Construct the two circles through the given points which touch the given straight line. Join the points of contact to the given points. The greater of the two angles thus formed is the required maximum. Each of the angles is a maximum among those having their vertices on the same side of the join of the given points. For, if the circle through the

given points A and B touches the given line at C, angle ACB> angle ADB where D is any point on the given straight line other than C and on the same side of AB that C is.

II. *Solution by M. Helen Kelley, Wilmette, Ill. (a student in Englewood High School).*

Let CD be the given line and A and B the given points. Draw AB and extend it to meet CD at P. Construct the mean proportional, PO, between AP and BP. Lay off PO on CD on the side of the acute angle. Construct the circle passing through the points O, A and B. The circle is tangent to CD. The angle AOB is measured by half the arc AB and any other angle with vertex on CD is measured by half the difference of two arcs, of which AB is the greater. Therefore, the angle AOB is the maximum angle.

438. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

Construct a circle that shall be tangent to a given straight line and coaxial with two circles that are nonintersecting and not tangent.

I. *Solution by Norman Anning, Clayburn, B. C.*

First construct the common center line of the two circles and their radical axis. To construct the radical axis of two given circles, draw any third circle cutting one in A and B, the other in C and D. Then AB and CD intersect on the radical axis. Similar construction with a fourth circle gives another point on the axis. Join the two points so found.

I. Suppose the given line not parallel to the radical axis. Then the two lines will intersect in some point not at infinity. Call it K and draw KL tangent to either of the given circles. With center K and radius KL, describe a circle cutting the given line in points M and N.

Draw MP ⊥ BN to meet the center line of the circles in P.

Draw NQ ⊥ MN to meet the center line of the circles in Q.

Then circles with centers P and Q and radii PM and QN respectively are coaxial with the given circles and touch the given line.

II. Suppose the given line parallel to the radical axis. Let r be the radius of the required circle, let h be the distance from the radical axis to the given line, and let d be the distance from the radical axis to a limiting point of the coaxial system. Then, when $h>d$,

$$\sqrt{d^2+r^2}+r=h.$$
$$d^2+r^2=h^2-2hr+r^2.$$
$$0\cdot r^2-2hr+h^2-d^2=0.$$
$$r=\infty,\ \frac{h^2-d^2}{2h}.$$

similarly, when $h<d$,

$$\sqrt{d^2+r^2}-r=h.$$
$$0\cdot r^2+2hr+h^2-d^2=0.$$
$$r=\infty,\ \frac{d^2-h^2}{2h}.$$

When $h=d$, $r=\infty, 0$.

After r has been constructed from the known quantities h and d, it must be measured on the center line from the given line in such a direction that when the circle is drawn, it will contain one of the limiting points of the system.

II. *Solution by N. P. Pandya, Sojitra, Dt. Petlad, India.*

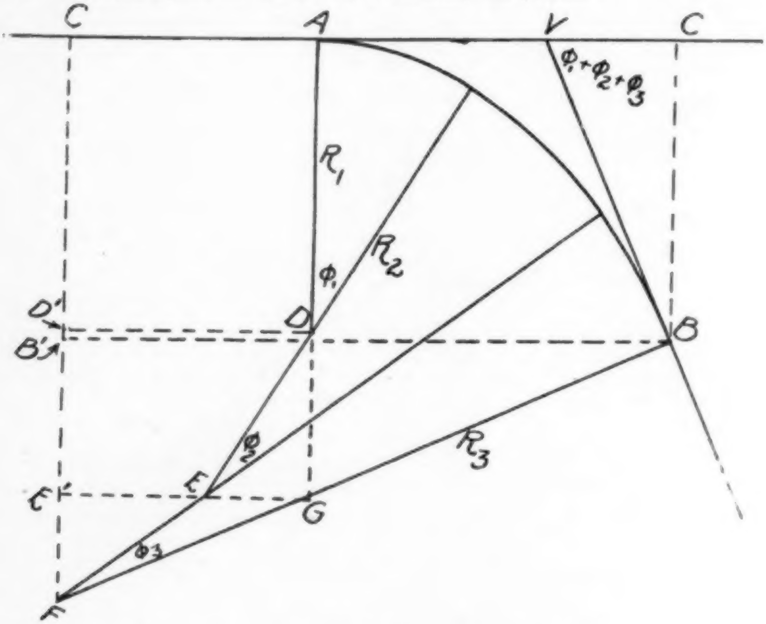
Let the radical axis of the given circles meet the given line in A and let their line of centers meet the given line in B. From A draw AC to touch one of the given circles at C. From AB cut off AD = AC. Draw DE perpendicular to AB to meet the line of centers in E. Then the circle with E as center and ED as radius will be the required one, because the tangents from A, which is a point on the radical axis, to all the circles are equal, and because ED is perpendicular to AB.

Trigonometry.

439. *Proposed by Norman Anning, Clyburn, B. C.*

AV and BV are two straight lines which differ in direction by an angle $\phi_1+\phi_2+\phi_3$. The points A and B are joined by a "three-center compound," i. e., a smooth curve consisting of three circular arcs and having VA and VB as tangents. If starting from A, the radii and central angles, are, respectively, R_1, ϕ_1; R_2, ϕ_2; R_3, ϕ_3; show that $VB\sin(\phi_1+\phi_2+\phi_3) = R_1+(R_2-R_1)\cos\phi_1+(R_3-R_2)\cos(\phi_1+\phi_2)-R_3\cos(\phi_1+\phi_2+\phi_3)$.

I. *Solution by A. E. Smothers, Pasadena, California.*



Starting with A call the centers of the arcs D, E, and F.

Then $AD = R_1$; $DE = R_2-R_1$; $EF = R_3-R_2$; and $FB = R_3$.

Draw $BC \perp$ to AV (produced if $\phi_1+\phi_2+\phi_3<90°$).

Then $BC = VB \cdot \sin(\phi_1+\phi_2+\phi_3)$.

Draw $FC' \perp$ to VA (produced if necessary), and $EG \perp$ to AD (produced if $R_2>R_1$).

Then $\angle EDG = \phi_1$; $\angle EFC' = \phi_1+\phi_2$; and $\angle BFC' = \phi_1+\phi_2+\phi_3$.

Call the projections of CB, AD, DE, EF, and BF on C'F, C'B', C'D', D'E', E'F', and B'F, respectively.

Then $C'B' = C'D'+D'E'+E'F-B'F$.

But $C'B' = CB = VB \cdot \sin(\phi_1+\phi_2+\phi_3)$; $C'D' = AD = R_1$; $D'E' = DG = (R_2-R_1) \cdot \cos\phi_1$; $E'F = (R_3-R_2) \cdot \cos(\phi_1+\phi_2)$; and $B'F = R_3\cos(\phi_1+\phi_2+\phi_3)$.

Substituting: $VB \cdot \sin(\phi_1+\phi_2+\phi_3) = R_1+(R_2-R_1)\cos\phi_1+(R_3-R_2) \cdot \cos(\phi_1+\phi_2)-R_3 \cdot \cos(\phi_1+\phi_2+\phi_3)$.

Q. E. D.

II. *Solution by the proposer.*

Let AC, CD, DB be the three arcs composing the compound curve and let O_1, O_2, O_3 be the respective centers.

We have $AO_1 \perp VA$ and $BO_3 \perp VB$.

Since the curve is "smooth" at C, the radii CO_1 and CO_2 must be parts of the same straight line. Similarly, DO_2 and DO_3.

Project the sides of the closed figure $AO_1CO_2DO_3BVA$ on the line AO_1. $R_1 - R_1 \cos \phi_1 + R_2 \cos \phi_1 - R_2 \cos (\phi_1 + \phi_2) + R_3 \cos (\phi_1 + \phi_2) - R_3 \cos (\phi_1 + \phi_2 \phi_3) - BV \sin (\phi_1 + \phi_2 + \phi_3) + 0 = 0.$

Therefore, $BV \sin (\phi_1 + \phi_2 + \phi_3) = R_1 + (R_2 - R_1) \cos \phi_1 + (R_3 - R_2) \cos (\phi_1 + \phi_2) - R_3 \cos (\phi_1 + \phi_2 + \phi_3)$.

Q. E. D.

Similarly,

$AV \sin (\phi_1 + \phi_2 + \phi_3) = R_3 + (R_2 - R_3) \cos \phi_3 + (R_1 - R_2) \cos (\phi_3 + \phi_2) - R_1 \cos (\phi_3 + \phi_2 + \phi_1)$.

These expressions may be readily modified to fit the compound curve of two, four or any greater number of centers.

440. *Proposed by Nelson L. Roray, Metuchen, N. J.*

If b, c, B are given, and there are two triangles with these given parts, show that their inscribed circles touch if

$$c^2(\cos B + 2\cos B - 3) + 2bc(1 - \cos B) + b^2 = 0.$$

I. *Solution by Elmer Schuyler, Brooklyn, N. Y.*

Let r_2, r_1 be the radii of the circles, and s_2, s_1 the half-perimeters of the two given triangles.

Since the condition imposed is that the distance between the centers of the circles equals $r_2 + r_1$, we obtain readily,

$$\frac{r_2 - r_1}{r_2 + r_1} = \sin \tfrac{1}{2} B \qquad (1)$$

But $r_2 = (s_2 - b) \tan \frac{1}{2} B$ and $r_1 = (s_1 - b) \tan \frac{1}{2} B$.

Substituting in (1) we obtain,

$$\sin \tfrac{1}{2} B. = \frac{s_2 - s_1}{s_2 + s_1 - 2b}, \qquad (2)$$

$$\text{and } \sin \tfrac{1}{2} B. = \frac{\sqrt{b^2 - c^2 \sin^2 B}}{c \cos B + c - b}. \qquad (3)$$

Squaring (3) and substituting equivalent forms,

$$\frac{1 - \cos B}{2} = \frac{b^2 - c^2 + c^2 \cos^2 B}{(c \cos B + c - b)^2}. \qquad (4)$$

$$c^2(\cos^3 B + 3\cos^2 B - \cos B - 3) + 2bc(1 - \cos^2 B) + b^2(1 + \cos B) = 0. \qquad (5)$$

Taking out factor $1 + \cos B = 0$,

$$c^2(\cos^2 B + 2\cos B - 3) + 2bc(1 - \cos B) + b^2 = 0. \qquad (6)$$

Q. E. D.

II. *Solution by Norman Anning, Clayburn, B. C.*

Suppose the in-circles touch, to find the relation between b, c and B. Since both circles touch the arms of angle B, the contact cannot be internal. Therefore the distance between the centers is equal to the sum of the radii. Use suffix 1 to denote parts of the smaller triangle and suffix 2, of the larger, and let O_1 and O_2 be the in-centers.

$$r_1 + r_2 = \overline{O_1O_2}.$$

$$r_1 = (s_1 - b) \tan \frac{B}{2}.$$

$$r_2 = (s_2 - b) \tan \frac{B}{2}.$$

$$2s_1 = b + c + c \cos B - \sqrt{b^2 - c^2 \sin^2 B}.$$

$$2s_2 = b + c + c \cos B + \sqrt{b^2 - c^2 \sin^2 B}.$$

$$\overline{O_1O_2} \cos \frac{B}{2} = (s_2 - b) - (s_1 - b),$$

$$= s_2 - s_1 = \sqrt{b^2 - c^2 \sin^2 B}.$$

$$r_1 + r_2 = (s_1 + s_2 - 2b) \tan \frac{B}{2},$$

$$= (b + c + c \cos B - 2b) \tan \frac{B}{2},$$

$$=(c+c\cos B-b)\tan\frac{B}{2}.$$

But since $r_1+r_2=\overline{O_1O_2}$ we have,

$$(c+c\cos B-b)\sin\frac{B}{2}=(r_1+r_2)\cos\frac{B}{2}=\overline{O_1O_2}\cos\frac{B}{2}=\sqrt{b^2-c^2\sin^2 B}.$$

$$(c+c\cos B-b)^2(2\sin^2\frac{B}{2})=2(b^2-c^2\sin^2 B).$$

$$[c^2(1+\cos B)^2-2bc(1+\cos B)+b^2]\ (1-\cos B)\ =\ 2b^2-2c^2(1-\cos^2 B).$$

$[c^2(1+\cos B)^2-2bc(1+\cos B)]\ (1-\cos B)+b^2-b^2\cos B\ =\ 2b^2-2c^2$ $(1-\cos^2 B)$.

$(1+\cos B)\ [c^2(1-\cos^2 B)-2bc(1-\cos B)]\ =\ (1+\cos B)\ [b^2-2c^2(1-\cos B)]$.

Dividing through by $(1+\cos B)$ which is not zero,

$$c^2(\cos^2 B+2\cos B-3)+2bc(1-\cos B)+b^2=0.$$

CREDIT FOR SOLUTIONS.

431. (April.) L. C. Mathewson.
431, 432, 433, 434, 435. (May.) Nelson R. Roray.
436. Norman Anning, Mabel G. Burdick, Alfred Davis, Ida May Davis, R. M. Mathews, Carrie Mikesell, G. O. Mudge, N. P. Pandya, George Raynor, Elmer Schuyler, Ruth Shockley, Nelson L. Roray. (12)
437. Norman Anning, T. M. Blakslee, Mabel G. Burdick, M. Helen Kelley, L. E. A. Ling, R. M. Mathews, N. P. Pandya, Elmer Schuyler, Nelson L. Roray. (9)
438. Norman Anning, Mabel G. Burdick, N. P. Pandya, Elmer Schuyler. (4)
439. Norman Anning, Lewis Braverman, A. E. Smothers. (3)
440. Norman Anning, Nelson L. Roray, George Raynor, Elmer Schuyler, one incorrect solution. (5)

Total number of solutions, 39.

PROBLEMS FOR SOLUTION.

Algebra.

451. *Proposed by N. P. Pandya, Sojitra, Dt. Petlad, India.*

Find three numbers, or different sets of three numbers each, such that their sum is a perfect cube, and the sum of their squares is a perfect fourth power.

452. *Proposed by Harold B. Clapp, Willimantic, Connecticut.*

$$\text{Solve, } \frac{2m}{e^v}=\frac{v+m}{v-m},$$

where e is the base of the Naperian logarithms and m is a constant.

Geometry.

453. *Proposed by Katherine S. Arnold, Milwaukee, Wisconsin.*

If lines be drawn from a fixed point to all the points of the circumference of a given circle, the locus of all their points of bisection is a circle. Two cases—the point may be within or without the circle.

454. *Proposed by Yeh Chi Sun, Peking, China.*

Given the three altitudes of a triangle, construct the triangle.

Trigonometry.

455. *Proposed by H. E. Trefethen, Waterville, Maine.*

Given $\tan\alpha+\cos\epsilon\tan\lambda$, and $\epsilon=23°\ 27'$. Find λ for maximum and minimum values of $\lambda-\alpha$.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

198. *Proposed by John C. Packard, Brookline, Mass.*

A fast skater collides with a slow one. Who gets the worse bump? (From Mann & Twiss.)

199. *Proposed by S. Ralph Powers, Terre Haute, Ind.*

The following equations have always been more or less troublesome to me from the standpoint of presentation and I would be glad to have an expression of opinion concerning them through School Science and Mathematics:

$$3Cu+8HNO_3 \rightarrow 3Cu(NO_3)_2+2NO+4H_2O.$$
$$Cu+2H_2SO_4 \rightarrow CuSO_4+SO_2+2H_2O.$$

Kindly answer consecutively numbered questions in the following list:

Harvard University Physics—New Plan.

June, 1915—One Hour and a Half.

(Omit four questions.)

200. A 50-gallon tank containing air at atmospheric pressure (15 pounds per square inch) is connected by a pipe to the city water mains, the pressure in which is 60 pounds per square inch. Assuming that the air remains at constant temperature, how many gallons of water will flow into the tank?

2. A uniform beam 10 feet long and weighing 50 pounds rests on a support 4 feet from one end, and is to be kept horizontal by a vertical force at some one other point.

(*a*) Where must this vertical force be applied in order that it may be as small as possible? Find its magnitude and direction (up or down).

(*b*) Where must this vertical force be applied to make the pressure on the support as small as possible, and how great is the force and how great is the pressure on the support?

3. (*a*) What is *friction?* Define *coefficient of friction.*

(*b*) In what ways is friction useful and in what respects is friction a disadvantage to mankind? Illustrate by examples.

(*c*) How can friction between rubbing surfaces be reduced?

201. A moving stairway moves at the rate of 2 feet per second. The maximum number of people who can ride on the stairway at any one time is 120. The length of the stairway is 50 feet and its vertical rise is 30 feet.

(*a*) Neglecting friction and assuming that the average weight of one person is 150 pounds, what is the maximum power required to operate the stairway?

(*b*) If the efficiency of the system is 60 per cent, what is the maximum power required?

202. (*a*) A musical note of 250 vibrations per second travels in air with a velocity of 340 meters per second when the temperature is about 13°C. What is the length of the wave?

(*b*) Calculate the number of vibrations in the fundamental note emitted at 13°C. by a closed organ pipe one meter long.

203. A certain fireless cooker consists of a main receptacle which contains a can for receiving the substance to be cooked and two soapstone disks or heat reservoirs. The main receptacle is covered on the outside with some heat-insulating substance to reduce the loss of heat from the interior. The aluminum lining of the main receptacle and the aluminum cooking can together weigh 1000 grams and are initially at 20°C. The soapstone disks weigh 3000 grams each and are heated to 300°C. before being placed in the cooker. The specific heats of aluminum and soapstone are respectively 0.22 and 0.21.

(*a*) A roast weighing 2000 grams and initially at 20°C., is placed in the cooker with the heated disks. The specific heat of the roast is 0.92. What is the temperature of the roast when the temperature of everything inside the cooker has become the same, assuming no appreciable loss of heat during the process of equalization of temperature?

(*b*) What would be the temperature of the roast if it had been previously heated to 100°C.? Does preheating help appreciably?

7. Name several methods by which heat can be transformed into other forms of energy. Describe in detail one of these methods.

8. The light from a candle falls on the page of a book two feet away. A large plane mirror, assumed to be a perfect reflector, is placed one foot from the candle on the opposite side from the book and with its plane perpendicular to the line passing through the book and the candle. Compare the illumination of the book with and without the mirror in place. How does this arrangement of candle and mirror differ from that of two candles and no mirror, the second candle replacing the image in the first arrangement?

9. (*a*) Explain the difference between the phenomena of reflection from white blotting paper and from a piece of window glass.

(*b*) It is often possible to see two or more images of a light reflected in a piece of plate glass. Explain this fact.

10. The resistance of a certain wire 10 feet long and 1/50 of an inch in diameter is 2 ohms. Calculate the resistance of the wire made by drawing down the above wire until its diameter is 1/100 of an inch.

11. (*a*) Explain a method of determining the sign (positive or negative) of an electrostatic charge.

(*b*) Explain the apparently different phenomena shown by so-called static electricity and the electricity given by a battery or a dynamo.

12. Two cells, each of electromotive force 2 volts and internal resistance 1 ohm, are to be used to light a small electric light of resistance 1 ohm. Show two methods of connecting the cells and calculate for each case the power supplied to the lamp. Which is the better arrangement and why?

Solutions and Answers.

186. *Proposed by W. L. Baughman, East St. Louis, Ill.*

Find the depth of a mine at the bottom of which a seconds pendulum loses 9 seconds a day.

Solution by the proposer.

The number of vibrations "lost" for a small decrease in the value of g is found as follows:

Let n equal the number of vibrations for a value, g.

Let n' equal the number of vibrations "lost" for a value, $g-k$, where k is the decrease in g. The number of vibrations is directly proportional to the square root of the corresponding values of g and $g-k$. Then we have that

$$\frac{n-n'}{n}=\frac{(1-k/g)^{\frac{1}{2}}}{1} \text{ and } \frac{n'}{n}=\frac{k}{2g} \qquad (1)$$

Now for a point within the earth, gravity varies as the distance from the center of the earth. Hence, at a depth d,

$$\frac{g-k}{g}=\frac{R-d}{R} \text{ and } \frac{k}{2g}=\frac{d}{2R}. \qquad (2)$$

From equations (1) and (2), $d=\frac{2Rn'}{n}$, where

$d=$ depth of the mine.

$R=$ radius of the earth; taken here as 3,963 miles.

$n=$ number of vibrations of a seconds pendulum in 24 hours.

$n'=$ number of vibrations "lost" in the mine.

$$d=\frac{2Rn'}{n}=\frac{2\times3{,}963\times5{,}280\times9}{60\times60\times24}=4{,}359.3 \text{ ft.—}\textit{Ans.}$$

187. *From "Book of Boats," Gray Motor Co., Detroit, Mich.*

What power will be required to drive a boat 20 ft. long, 52 in. beam, at 11 miles an hour?

From a letter to Gray Motor Co. from S. F. Mills, Ann Arbor, Mich.

We have one of your 1909 Model, 6 h. p., double cylinder engines installed in the "Grayling," length 20 feet, beam 4 ft. 3 inches. The hull is strongly but not heavily built with the motor installed forward under a hood with magneto, clutch, foot throttle, etc.

Over a measured course we have made 11 miles an hour. With the Krice Carburetor which we put on last year, we can go from 10 to 12 miles on a gallon of gasoline.

From a letter by H. H. Hellmuth, Mgr. Marine Sales, Gray Motor Co.

There is no hard and fast rule in which the answer to the query can be worked out. Everything depends on the model of the boat, weight, construction, water in which it will operate, etc.

A well designed boat 20 ft. long, of the runabout class, 52 in. beam, should make 11 miles per hour or better with a 6 h. p. Gray engine.

188. *From Scientific American Correspondence.*

Why in very cold weather are meat or vegetables more likely to freeze in a refrigerator or refrigerator car containing no ice than in one supplied with ice?

A suggested answer.

In the car supplied with ice not only the meat or vegetables must be cooled to a freezing temperature but also the ice and water associated with them. If water is present, it will liberate 536 heat units per gram on freezing. Also the ice formed has a specific heat of about .5 and so will cool more slowly because it will absorb considerable heat. Both effects keep the temperature from dropping as rapidly as though no ice were present.

Solution by A. G. Montgomery, Concord State Normal, Athens, W. Va.

189. *Proposed by A. Haven Smith, Riverside, Cal.*

What is the numerical value of the heat of vaporization of water at temperatures other than 100°C?

The heat of vaporization of water is less at high temperatures than at low as might be expected; thus to evaporate 1 gram of water at 100°C. takes 536.6 calories of heat, while 596.73 calories are required if the vaporization takes place at zero degrees centigrade.

The latent heat l required to vaporize a gram of water at any temperature t may be determined from the following formula which expresses the results of Griffith's experiments:

$$l = 596.73 - 0.601t,$$

where t is the temperature of vaporization on the centigrade scale.

Answer by Niel Beardsley, Bloomington, Ill.

Kimball and also Carhart in their *College Physics* give the following formula attributed to Griffith: $l = 596.73 - .601t$ cal. in which t is the Centigrade temperature. This formula is not good for temperatures much beyond 0° and 100°C.

190. *Proposed by Mary F. Morris, Newtown, H. S., Elmhurst, N. Y., taken from Wentworth's Advanced Arithmetic, p. 374. Ex. 30.*

Find the difference in length at 80°F., of a glass rod and a steel rod, each 3 ft. long at 0°C., if the expansion at 100° C. is 0.00085 for glass and 0.0012 for steel.

Solution by Editorial Dept. of Ginn & Co.

$80°\text{F.} = \frac{5}{9}(80° - 32°)\text{C.} = 26\frac{2}{3}°\text{C.}$

$0.0012 - 0.00085 = 0.00035.$

$$\text{Difference in length} = \frac{26\frac{2}{3}}{100} \times 0.00035 \times 36 \text{ in.} = 0.00336 \text{ in.}\text{—}\textit{Ans.}$$

Solution by Niel Beardsley.

$80°\text{F} = 26.66°\text{C.}$

$$\frac{.0012 - .00085}{100} \times 26.66 \times 3 = .00027993 \text{ ft. which is the difference in length.}$$

ARTICLES IN CURRENT PERIODICALS.

American Forestry, for October; *Washington, D. C.; $3.00 per year, 25 cents a copy:* "The American Chestnut Tree—Identification and Characteristics" (with six illustrations), Samuel B. Detwiler; "Commercial Uses of Chestnut" (with twelve illustrations), P. L. Buttrick; "Chestnut in the Future" (with one illustration); "Principles of Landscape Forestry—Art of Managing Pleasure Woods" (with ten illustrations), Wilhelm Miller; "The Bird Department" (with four illustrations), A. A. Allen; "Forestry at the Exposition"; "National Conservation and Water Powers" (with five illustrations), Herman H. Chapman; "Ornamental and Shade Trees—How to Plant a Shade Tree and How to Care for It the First Few Years" (with seven illustrations), J. J. Levison.

Condor for September-October; *Los Angeles, Hollywood Station, Calif.; $1.50 per year, 30 cents a copy:* "Characteristic Birds of the Dakota Prairies. I. In the Open Grassland," Florence M. Bailey; "A Walking Eagle from Rancho la Brea" (with one photo), Loye H. Miller; "Estimated Average Age of the Herring Gull," John T. Nichols; "A Late Nesting Record for the California Woodpecker," Harriet W. Myers; "Description of a New Race of Savannah Sparrow and Suggestions on Some California Birds," Louis B. Bishop; "A Partial List of the Summer Resident Land Birds of Monterey County, California" (with map and five photos), J. R. Pemberton and H. W. Carriger.

Journal of Geography for October; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "The Growth of Great Cities," Frederick Homburg; "Overlooked Bohemia," Eugene Van Cleef; "Harbors of South America," Henry F. James; "Glaciers and Glaciation of South America," Walter H. Schoewe; "Outline for the Study of Frost and Protection against Frost," William G. Reed; "The Discovery of the Painted Stone, an Early Observation of the Driftless Area," Lawrence Martin.

National Geographic Magazine for September; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "The Warfare on Our Eastern Coasts" (with thirteen illustrations and two maps), John O. La Gorce; "Historic Islands and Shores of the Ægean Sea" (with twenty-eight illustrations and one map), Ernest L. Harris; "London" (with twenty-nine illustrations), Florence C. Albrecht.

Nature-Study Review for September; *University of Chicago, Chicago, Ill.; $1.00 per year, 15 cents a copy:* "A Study of Spiders," Alice J. Patterson; "Learning to Read a Roadside," G. M. Goethe; "Nature Play in the Mountains," Charles L. Edwards; "Our School Gardens," Bessie Cooper; "Activities of One Live Rural School Teacher"; "The Public School as a Neighborhood Center," Mable Carney.

School Review for October; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "High School Costs," J. F. Bobbitt; "The Problem of Individual Differences in the Teaching of Secondary-School Mathematics," Raleigh Schorling; "Segregation at the Broadway High School, Seattle," Thomas R. Cole.

School World for October; *London, Eng.; 7s. 6d. per year, 6d. a copy:* "Sketch Maps in Geography" (with diagrams), E. R. Wethey; "The Military Training of Youth in Schools. A Review of Systems of Training in the British Empire and in Various Foreign Countries. I," A. B. Wood; "Schoolbooks and Eyesight" (with diagram); "The Educational Value of History," F. J. C. Hearnshaw; "Educational Retrospect and Outlook. The Presidential Address to the Educational Science Section of the British Association," Mrs. Henry Sidgwick; "Methods and Content of History as a Subject of Study in Schools," Ramsay Muir.

Physical Review for October; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "Magnetization by Rotation," S. J. Barnett; "Electrostatic Measurement of Electrode Potentials," Arthur W. Ewell; "Leakage of Gases Through Quartz Tubes," E. C. Mayer; "The Geiger Apparatus for the Photographic Registration of Alpha and Beta Particles," J. E. Shrader; "A Mechanical Process for Constructing Harmonic Analysis Schedules for Waves Having Even and Odd Harmonics," Hawley O.

Taylor; "The Change in the Elasticity of Aluminum Wire with Current and External Heating," H. L. Dodge.

Zeitschrift für den Physikalischen und Chemischen Unterricht for September; *in Berlin, W. 9, Link Sts. 23-24; 6 No. $2.88 M. 12 per year:* "Zement und Beton im chemischen Unterricht und als Hilfsmittel der Laboratoriumspraxis," O. Ohmann; "Demonstrationsapparate für Schwingungen von Systemen mit zwei Freiheitsgraden und Theorie derselben," H. J. Oosting; "Der Drehstrom-Schwingungsschreiber," F. Fricke; "Über das Chemiestudium und eine systematische Einteilung der gesamten chemischen Disziplinen," P. Verbeek; Kleine Mitteilungen: "Betrachtungen zum Keil, zum Hebel und zum Böschungswinkel," A. Stroman; "Über Luftspiegelung," W. Volkmann; "Konstruktion der Brechung und Zurückwerfung für mehrere Strahlen, die in einem Punkte einer Ebene auftreffen," R. Glass; "Die Gewinnung von Salpetersäure aus Luftsstickstoff mit Hilfe des Lichtbogens," F. Keutel; "E. Magin, Ein einfacher Schwimmversuch," Versuche mit einfachen Mitteln; "P. Hanck, Selbstanfertigung eines v. Waltenhofenschen Pendels—F. Küspert, Bemerkungen zu einigen Versuchsanordnungen," Für die Praxis.

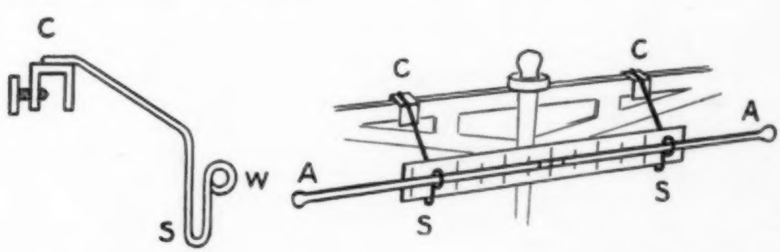
ACCURATE WEIGHING WITHOUT THE USE OF SMALL WEIGHTS.

By George W. Todd,

Newcastle-upon-Tyne.

Perhaps nothing disturbs the peace of mind of teachers of science so much as the loss of the small aluminium fractions of a gram in the weight box of a balance. Sometimes these weights have to be renewed more than once a term. The following device, which may easily be attached to the beam of any balance, will admit of weighings to the third place of decimals without the use of small weights.

The small clamps C, to which the ends of the wires, CS, CS, are soldered, fix on to the balance beam. The wires should be of copper or brass bent to the shape shown in Figure 1, and the clamps should be at least 10 cm. apart. A millimetre scale gummed to a strip of celluloid fits tightly into S S (Figure 2). Weighing is effected by the movement of an aluminum rod, A A, which threads the loops, W W. This rod will not get lost easily especially if the ends of it are enlarged so as to prevent them slipping through the loops. The rod should be about the length of the balance beam, and its position on the scale can be indicated by a small piece of paper gummed to the rod.



Let the length of half the balance beam be b millimetres. Then if the aluminium rod weighs R grams, a motion of 1 mm. along the scale corresponds to the addition of R/b grams to the scale-pan opposite to the direction of motion of the rod.

Now if the maximum motion of the rod, 10 cm. say, is to read up to one gram, the weight of it must be such that a movement of 1 mm. corresponds to 0.010 gm. The third place of decimals should be estimated easily.

Putting $R/b = 0.010$ gm., we get the following weights of the rod for varying balance beams:

Length of ½ beam......... 10 cm.......... 11 cm.......... 12 cm. } etc.
Weight of rod .... 1.00 gm......... 1.10 gm......... 1.20 gm. }

An aluminium rod 20 cm. long, weighing 1 gm., would have a diameter of approximately 1⅓ mm., and would be quite rigid enough to be supported without sagging. The rod must be below the level of the knife-edge, but not too far below, or the sensitiveness of the balance will be affected. By bending the wires one can adjust the level of the rod to give a suitable sensitiveness to the balance.

The writer has used such an arrangement as described above and finds that while the accuracy is at least as good as that obtained with the use of small weights, the operation of weighing is performed in much less time because weights have not to be put on and taken off continually. In addition there is the advantage that a rod of aluminium 20 cm. long is not so easily lost as minute pieces of aluminium foil.—*The School World.*

THE RIGID COURSE.

There has grown up in the American system of secondary school education, a strong sentiment among some of our best educators, to the effect that high school pupils should be held very largely to a prescribed and definite course. They believe that the number of electives should be reduced to such a minimum that there is practically no opportunity for the pupil to select anything outside of the course with which he has connected himself.

The writer believes that this is entirely wrong and that it is not productive of the best educational results. Over against the group of instructors already referred to, there is a large and increasing number who believe that the courses should be very elastic, and that the pupil should have, within reasonable limits, considerable latitude in the selection of his studies. Everyone will admit that any prescribed course can not be the best for every boy and girl. It is absolutely impossible to fill a square hole with a round stick, even though the diameter of the stick may be equal to one of the sides of the square. There are many subjects outside of the prescribed courses, which have just as much educational value as those which may be given in the best courses which are now offered in our leading secondary schools. As it is in many cases at present, pupils are obliged to pursue studies for which they have absolutely no love, the result being that the benefit derived from the pursuit of such a study is almost nothing; whereas everyone knows that if the pupil can be given something in which he is interested and for which he has a special faculty, he will enter into the game of studying that subject with vim and interest, and with the result that he will become proficient in it.

It seems to the writer that if on the basis of sixteen credits for graduation, at least half of these were made elective—not entirely depending on the whim of the pupil but on consultation with parent, principal, and teacher—the result would be far more beneficial to the pupil than under the rigid course regime. Likewise many of our

pupils who now leave high school before graduation, would be induced to remain. Indeed the writer is almost of the belief that he would compel the pupil to take only six of the sixteen credits, all the others being elective. He would insist that English be required for at least three years.

It has been the observation of many instructors that where the pupil, under proper supervision, has selected elective studies, he almost invariably makes good. Our schools are not for the purpose of crowding down the intellectual esophagus, subjects that are abhorrent to the pupil, but they are more for leading the young person into those directions which will be congenial to him, and at the same time allow him to pursue those studies for which he has a special aptitude, and which will enable him to become the highest type of citizen.

ERRORS IN RAILROAD MAPS.

It is a notorious fact that many of the railroad and steamship maps of this country are so far removed from anything corresponding to an accurate United States Geological Survey map, that they amount to absolutely nothing as far as giving a correct idea of direction or distance of the country through which the railroads pass. Many of these maps make the particular railroad represented, pass in practically a straight line between the larger railroad centers. Then, too, the area of the territory and the boundaries of states are distorted out of all resemblance to the truth. Young people necessarily get an erroneous idea of their country in studying these maps, and foreigners often gain their only knowledge of the nature and extent of the land from the maps which the railroads place in their hands.

It is time something is being done to compel our common carriers to issue maps in conformity with the United States Geological Survey. Resolutions will be introduced at the coming meeting of the Central Association of Science and Mathematics Teachers, with the idea in mind of requesting Congress to pass a Bill compelling the railroads and steamship companies, in issuing their maps, to conform absolutely to the maps of the United States Government. It is hoped that all science and educational associations will assist in the movement to bring about this end. All people who are interested in having this abortion corrected are requested to write to their Congressmen asking them to use their influence in passing a Bill that will compel the railroads to issue maps that are correct.

SCIENCE SECTION MEETING OF THE NEW YORK STATE TEACHERS' ASSOCIATION.

The next meeting of this Association will occur in the West High School, Rochester, New York, on November 22nd to 24th. A very interesting and helpful program has been arranged. Among some of the subjects are the following: "Some Interesting Phases of Bird Study," by Prof. A. A. Allen, Cornell University; "How to See a Map," by Prof. Geo. H. Chadwick, University of Rochester; "Content Methods and Results of High School Study of Chemistry," by Prof. Alexander Smith; "Forestry," by Dean Hugh Baker, Syracuse University.

There will be a splendid exhibit of apparatus of one kind and another.

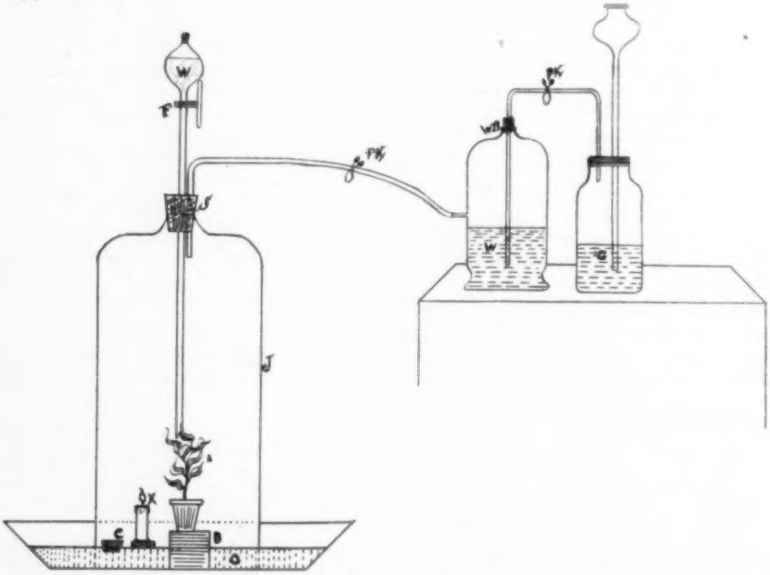
All science teachers of the state of New York should plan to be at this meeting. For further information, write to the Secretary, Harry C. Allen, High School, Niagara Falls, New York.

RESPIRATION IN PLANTS.

[The following account came to us from a pupil in a New York City high school. It appears to represent an interesting attempt at original investigation on the part of the pupil. While it is true that respiration in plants has been demonstrated by earlier investigators, and most of its phases are rather well known, the design of the apparatus described below appears to be original. There are certain criticisms of the experiment that might be made, however. Since the writer requests criticism, will not some of our botanical readers attempt a constructive criticism of the experiment? Send such criticism to the botanical editor.—*Editor.*]

The following is a description of an experiment which I performed last winter in my own home laboratory. I set out to demonstrate by experiment that a plant cannot live without oxygen, even if all other conditions are kept normal; in other words, that the process of respiration in plants is identical in principle with that in animals. I had never heard of or seen any similar experiment, either before or since.

So I began to figure it out, and finally I constructed a shelf at the window where the sun came most often, and set upon it the following apparatus:



From the diagram, it will be seen that I aimed to give my plant all the constituents of ordinary air and earth, and all other conditions, i. e., N_2, CO_2, NH_3 (traces), H_2O, sunlight and heat, but NO OXYGEN. That part of the apparatus marked B furnished the CO_2, of which I let in a small number of bubbles each day. The wash bottle prevented any H Cl fumes to get into J.

Each day I gave it a small quantity of H_2O by means of the drop funnel. It will be noticed that more water can be put into the funnel, and that the CO_2 generator can be detached and cleaned without affecting the rest of the experiment.

The sunlight it, of course, received from the window, and the radiator in the room kept the temperature up during the night. The stopper S was sealed with wax. I used oil in the pan because H_2O might contain dis-

solved air or oxygen. The original oxygen in J I eliminated by burning the candle X when I set up the apparatus. Any oxygen that may have remained, or, more important still, any which might have been given off during the progress of carbohydrate manufacture, as a by-product, was consumed by a piece of phosphorus in the crucible C floating on the oil. Thus I watched the experiment for over a week. As a side issue, one of the observations, interesting from a physical point of view, was that in the night, it being somewhat colder, the atmosphere in J contracted and the oil rose in the jar; during the day, the level of the oil was lower in the jar than in the pan.

At the end of three or four days my plant (corn plant), healthy when first put under the jar, showed signs of withering, i. e., turning brown and yellow. This could not have been for lack of water, for I carefully regulated the supply. It kept getting worse, till at the end of eight or nine days it died.

Perfect as I have tried to make the apparatus, I realize that there are several possible flaws in it; and herein lies the possibility that the result is not absolutely conclusive. Some day I hope to repeat it, perhaps with several modifications.

However, I believe it is an interesting experiment, as it is my first attempt at original experimental work in my favorite hobby and future life study, viz, biological chemistry. I give it for what it is worth; and will be greatly obliged for criticism or suggestions from any of the readers of the magazine.

WILLIAM L. SCHAAF,
Morris High School, N. Y. C.

A TYPICAL GOVERNMENT HIGH SCHOOL.

It is time that our national government set apart a sufficient sum of money for the purpose of establishing an ideal high school in some central locality of the country. In the construction of this school building every provision possible should be made for handling all phases of secondary school work with the highest possible degree of efficiency. In all of its departments the building should be equipped with devices of all descriptions which are most modern in their character, and which are conducive to the most successful teaching.

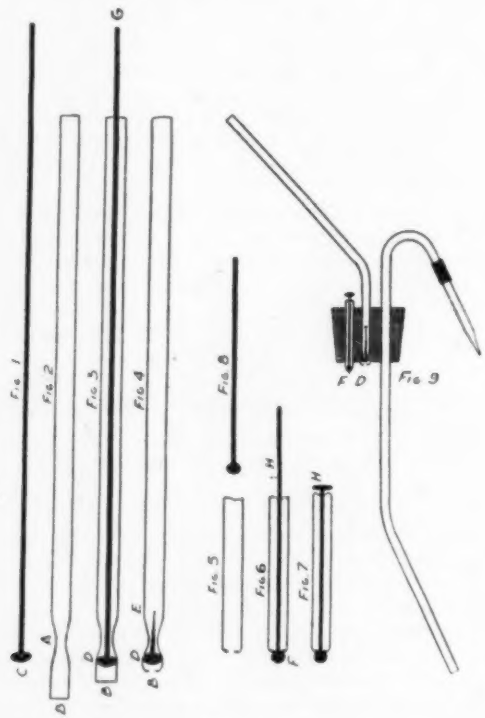
There are now being erected in all parts of our country secondary school buildings, many of them equipped in a modern manner, many having well-selected libraries and standard apparatus; yet at the same time they have not all the very best arrangement, nor have they the best apparatus, books and charts purcurable for the money expended. This proposed school would be a model in every respect, and a place to which Boards of Education might send committees and societies might send their representatives and instructors themselves might visit, in order to see demonstrated the most advanced equipment in secondary education. It is not intended that this school, when once established, should remain as it is finished, but new devices, new schemes, new apparatus, etc., when invented, should be tried out here. In other words, it should be kept absolutely up to date.

The value of such a school as this cannot be measured in dollars and cents. It would be the means of increasing the efficiency of secondary school teaching more rapidly than by any other plan now in operation. It is hoped that some energetic Congressman who is in touch with secondary school work in the country, will take this matter in hand and push it for all it is worth for the establishment of the best all-around secondary school in the world.

WASH BOTTLE VALVES.

By E. W. Gaither,
Wooster, Ohio.

Use $\frac{3}{8}$ inch medium wall soft glass tubing, heat on narrow flame, draw out stricture A (Fig. 2), cool and cut off $\frac{3}{8}$ to $\frac{1}{2}$ inch below stricture at B. Heat B and spread by inserting blunt ended piece of charcoal; heat again and make valve seat by rotating charcoal. This makes a wide angle seat and prevents the valve sticking.



Make an oval bead C on end of a glass rod (Fig. 1) cool, insert in tube as shown in (Fig. 3) add a little water and emery flour and grind seat D by rotating glass rod at G. When seat is thoroughly ground, wash out emery, draw out rod, cut off at E thereby dropping back into place, using a very small blast flame, heat tube at B and turn edges in so as to hold valve in place (Fig. 4). Cool and bend tube for mouthpiece. Cut a piece of glass tubing about 2 inches long (Fig. 5) and partly seal one end for valve seat. Make a round bead on end of of glass rod (Fig. 8), grind valve seat F, cut off $\frac{1}{2}$ inch longer than tube at H, partly seal the other end of tube and make irregular by pressing it slightly while hot, cool, insert valve and flatten end at H by heating. Assemble as in (Fig. 9).

By blowing through mouthpiece, valve F is closed, back pressure closses D, and flow of water continues until pressure is relieved by pressing down on F with thumb.—*The Chemist-Analyst.*

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

On Saturday, May 22nd, at St. Paul's School, Concord, New Hampshire, the seventy-first regular meeting of this Association was held. As is usual with all of the gatherings of this wide-awake company of physics teachers, this particular meeting was one of interest and helpfulness to everyone who attended.

The regular routine of business was first carried out, after which an address of welcome was given by the rector of the school, Rev. Samuel S. Drury. Following this, Prof. G. H. Hull of the Department of Physics of Dartmouth College gave an address on the "Reflection of X-Rays From Crystalline Surfaces." This address was something new and unique to the members present, Prof. Hull showing that he was in complete command of the subject. Following this address, the meeting adjourned for luncheon, which was served in the dining room of the Upper School. The afternoon session was begun by an address on "Transcontinental Telephony," by Mr. J. G. Patterson of the New England Telephone and Telegraph Company. This talk was listened to with the greatest interest, as the speaker gave the members of the Association something in which they were intensely interested. It brought them strictly down to date with reference to the science of telephony. This address was followed by Willard J. Fisher of the Department of Physics of the New Hampshire State College, on "Methods of Projecting Lecture Experiments." This talk was helpful and very much to the point. After adjournment of the session, the school plant was inspected.

The educational value of these meetings can hardly be estimated, as the members who attend are placed directly in touch with the leading thought on the subject of physics, and they secure an inspiration to keep abreast of the times. In this way they are making of themselves better all-round physics instructors.

THE ANNUAL 1915 MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The fifteenth annual meeting of the Central Association of Science and Mathematics Teachers will be held at Chicago in the new building of the Harrison Technical High School, November 26th and 27th. Plans for the meeting provide programs for the general sessions and section meetings, which include addresses, papers, and discussions on some of the most important topics now under consideration in secondary-school work.

At the general session on Friday morning, November 26th, addresses will be given by Earle R. Hedrick, professor of mathematics, University of Missouri, Cyril G. Hopkins, professor of agronomy, University of Illinois, and Edward H. Steiner, sociologist, Grinnell College, Iowa. The remarkable development of the high school in recent years and the new demands made upon it have given rise to questions of reorganization and administration, which affect the teacher as well as the pupil. The speakers at this session are peculiarly well fitted to deal with these questions, and teachers of science or mathematics in the territory of the association cannot afford to miss this opportunity of broadening their outlook on the practical problems of readjustment and getting suggestions of real value to aid in solving these problems in their own school.

On Friday evening, William B. Ittner of St. Louis, architect of the Board of Education of St. Louis, and one of the foremost architects of school buildings in the country, will give a most interesting and valuable address on school architecture, Mr. William R. Moss, Chicago Association

of Commerce, will give an address from the viewpoint of a business man as to what business demands of science and mathematics teaching, and Mr. A. A. Upham of the Whitewater Normal School, Wisconsin, will speak from a school man's point of view concerning the business management of our school systems.

The programs of the section meetings, Agriculture, Biology, Chemistry, Earth Science, Home Economics, and Mathematics, include papers by many of the ablest and most prominent teachers of the country. Committees appointed in the various section at the last annual meeting have been at work during the year and will report at this meeting. It is expected that ample time will be allowed in each section for general discussion. The program will be sent out early in November, and members are urged to come to the meeting prepared to take part in the discussion of papers.

All teachers of science and mathematics interested in making their work of greater value to pupils and to the community who have not availed themselves of the benefits of this Association, are cordially invited to attend this meeting and enroll themselves as members. Not the least pleasure and profit of attending the annual meetings of this Association is the opportunity it gives of renewing old friendships and forming new ones. The mutual exchange of ideas and experiences will furnish inspiration for the work of another year.

For programs and additional information, write the Secretary, Mr. A. W. Cavanaugh, Lewis Institute, Chicago.

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Sierra Educational News, San Francisco, Cal.
Southern School Journal, Lexington, Ky.
Teacher's Monograph, New York City.
Texas School Journal, Dallas, Texas.
Volta Review, Washington, D. C.
Western School Journal, Topeka, Kansas.
Western Teacher, Milwaukee, Wis.
Wisconsin Journal of Education, Madison, Wis.

BOOKS RECEIVED.

An Introduction to Science, by Bertha M. Clark, Wm. Penn High School for Girls, Philadelphia. 492 pages. 13x19 cm. Cloth. 1915. American Book Co., Chicago.

Miln's Second Course in Algebra, by Wm. J. Miln. 288 pages. 12x18 cm. Cloth. 1915. American Book Co., Chicago.

Soils—Their Properties and Management, by T. L. Lyon, Elmer O. Fippin, Harry O. Buckman, Cornell University. Pages xxi+764. 13x19.5 cm. Cloth. 1915. The Macmillan Co., New York City.

Chemistry in the Home, Henry T. Weed, Manual Training High School, Brooklyn, N. Y. 384 pages. 13x19 cm. Cloth. 1915. American Book Co., New York City.

Vest Pocket Handbook of Mathematics for Engineers, by L. A. Waterbury, University of Arizona, 2nd Edition. 213 pages. 7.5x14 cm. Cloth. 1915. John Wiley & Sons, New York City.

The Fish Notebook, by Geo. C. Embody, Cornell University. Pages 139. 12x19.5 cm. Paper. 1915. Comstock Pub. Co., Ithaca, N. Y.

First Book in French, by Eugene F. Maloubier, Adelphi College, and Justin H. Moore, College of the City of New York. Pages xiii+363. 13x19 cm. Cloth. 1915. $1.10. The Macmillan Co., New York City.

Farm Business Arithmetic, by Curtis J. Lewis. Pages xiii+199. 13x19 cm. Cloth. 1915. D. C. Heath & Co., Chicago.

Lessons in Elementary Physiology, by Thos. Huxley. Revised Edition. Pages xxvi+604. 13x19 cm. Cloth. 1915. The Macmillan Co., New York City.

Mathematics Tables for Classroom Use, by Mansfield Merriman. 67 pages. 13x19 cm. Cloth. 1915. Jn. Wiley & Sons, N. Y.

Grammar School Arithmetic, by Florian Cajori, Colorado College. Pages ix+437. 13:5x19.5 cm. Cloth. 1915. The Macmillan Co., New York City.

BOOK REVIEWS.

A Yearbook of Wireless Telegraphy, by the Marconi Co. Pages lxvi+800. 14.5x21.5 cm. Cloth. 1915. $1.50. Marconi Publishing Corporation, 450 4th Ave., New York City.

This book is by all odds the one which should be in the hands of all persons, both professional and amateur, who are interested in wireless telegraphy. There is in the book an interesting record of the development of wireless telegraphy from the time of Faraday's discovery of electromagnetic induction down to the present day. The various wireless laws and regulations are given, as well as an account of the international radiotelegraphic convention. A splendid account is given of the recent international convention on the safety of life at sea. The laws and regulations applying to wireless telegraphy, of the various nations of the earth, are given. Those appertaining to the United States are very complete. A list of the wireless stations of the world is given, as well as a long list of the ship stations. Probably every ship afloat, on board of which is a wireless outfit, is listed here. In this list the signal call, normal range in nautical miles, the line to which it belongs, wave lengths in meters, and the ship charge, are given. There are several papers by prominent men dealing with radiotelegraphy, printed in the body of the book. There is a splendid glossary of terms used in radio work, together with a dictionary of technical terms, printed in English, French, German, Swedish, and Italian. The book contains many illustrations—in fact it is filled from cover to cover with information and data of the highest value to all radio men. No person engaged in any way with wireless telegraphy can afford to be without this book. C. H. S.

First Year Course in General Science, by Clara A. Pease, High School, Hartford, Conn. 315 pages. 13.5x19 cm. Cloth. 1915. $1.20. Chas. E. Merrill Co., New York City.

This is a very interesting and helpful book, which has been produced in order to give a general, comprehensive view of science, rather than a

book of general information. It is intended primarily to teach first year pupils the relation and interdependence of the commonly recognized sciences, and to prepare them for intelligent work in any science offered in the high school during the last three years. The illustrations are apt and well selected, there being 161 of them. The volume is the result of years of experience in the Hartford High School. It surely is written in such an attractive style, and the particular subjects are so well chosen, that the first year high school pupil cannot help but become interested in it. It deserves a wide circulation. Mechanically, the book is well made, the type clear, and the major paragraphs are begun with bold-faced type.

C. H. S.

Mechanical Drawing, with Special Reference to the Needs of Mining Students, by Joseph Husband, University of Sheffield. 79 pages 22x28 cm. Paper. 1915. 80 cents. Longmans, Green & Co., New York City.

This is a splendid treatise on the art of mechanical drawing, every other page, at least, being devoted to practical drawings which are to be copied by the pupil. The first few pages are given over to the use and construction and manipulation of drawing instruments. The drawings progress in degree of difficulty from the very simplest to those of a complicated nature. Too much cannot be said in praise of these splendid drawings. They are correct in every detail. Mechanical drawing teachers, who instruct by the method of copying, cannot do better than to make use of this book.

C. H. S.

Read's Salesmanship, by Harlan E. Read. 296 pages. 14x20 cm. Cloth. 1915. Lyons & Carnahan, Chicago.

This is a book written in some such a manner as a former volume by the same author, but this is much more extended in its treatment of the subject. The psychology of the science of salesmanship is one of the

practical features of the book. It is well illustrated by charts and diagrams, which place the topics before the student in a correct fashion. One finds throughout the work requirements for practical work in real salesmanship. The book can be said to be in a class by itself in its adaptation of the subject of salesmanship to the needs of classroom work. The author is a practical salesman and a teacher of some years' experience. This is a volume which a great many old drummers ought to procure and read, and at the same time all people who expect to make salesmanship, either on the road or behind the counter or in the real estate office, their profession, should study the book thoroughly. C. H. S.

Francis W. Parker School Yearbook, Vol. IV. 187 pages. 15x22.5 cm. 70 illus. Paper. 1915. Francis W. Parker School, Chicago.

This is a book prepared by the faculty of this school, and it deals with "education through correct expression." It is a distinctive contribution to the literature of practical education, and presents in a variety of ways the work which is being carried out in this very interesting and unique school. The importance of providing adequate and correct experience and imagery as the basis of all school work, of motivating the work, of relating it to the needs and occupations of the children, and of carrying over the knowledge gained into purposeful activities, cannot be too strongly emphasized. The absence of proper opportunity in most schools to turn what is learned into practical use, is responsible in large measure for the dislike of the children for school work. This volume is filled with new and interesting articles on how to best secure and hold the attention of the pupil. It should be carefully read and studied by all school folk. C. H. S.

The Practical Conduct of Play, by Henry S. Curtis, Supervisor of Playgrounds, District of Columbia. Pages ix+330. 13.5x20 cm. Cloth. 1915. $2.00 The Macmillan Co., New York City.

A splendid book appearing at an opportune time, on a very practical subject, by a person abundantly qualified to present the matter of the science of play on the part of school children in all of its phases. Space will not permit of any detailed account, but we are urging all people interested in settlement work and in the better care of children, both in and out of doors, to secure a copy and become familiar with it. C. H. S.

Practical Applied Mathematics, by Joseph W. L. Hale, Associate Professor of Engineering, The Pennsylvania State College. Pages xi+206. 12x18 cm. $1.00. 1915. McGraw-Hill Book Company, Inc., New York.

While serving for five years as supervisor of apprentice schools of the Pennsylvania lines east of Pittsburgh and Erie, the author has been interested in organizing and developing a system of railroad shop apprentice schools. The results of his experience in this work and of his investigations of the work of various vocational and corporation schools of manufacturing industries and railroads has led to the preparation of this book. The material was chosen with the purpose of making the book usable not only in railroad schools but also in mechanical trade schools and in public schools.

The first five chapters deal with the fundamental operations of arithmetic and their applications; in the next five chapters the various problems of mensuration of plane figures are presented; the next five chapters introduce the student to the literal notation of algebra and the use of the equation; and the last five chapters deal with the surfaces and volumes of solids. Most boys have a fairly good knowledge of the practical material of the problems; and the careful arrangement and sequence of the entire work should make it a very useful and helpful book for use in the schools for which it is designed. H. E. C.

School Arithmetic, Intermediate Book, by Florian Cajori, Pages viii+299. 13x19 cm. 40 cents. 1915. The Macmillan Co., New York.

The method of presentation in the *Primary Arithmetic* by the same author is followed in this book. To make arithmetic attractive to the pupils without sacrifice of serious intent by furnishing problem material bearing on the practical life of today, to encourage the pupils to work out problems for themselves, and to secure greater economy of effort by simplifying the technique are some of the aims of the author. These aims seem to be realized. The large type, tabular arrangement of data and problems, and clear explanations in addition to the details already noted will render this a very teachable book. H. E. C.

Everyday Arithmetic, A Practical Mental Arithmetic, by John B. Gifford. Pages x+194. 14x19 cm. 35 cents. 1915. Little, Brown & Company, Boston.

The demand for more mental work in arithmetic seems to be on the increase; and this book, topically arranged and dealing with problems of everyday life, will commend itself to interested teachers. "In doing the world's work the tradesman, the man in the shop, and people in almost all walks of life use much more mental than written arithmetic." The subjects usually included in written arithmetics are treated in this book with discriminating perception. H. E. C.

Mortality Laws and Statistics, by Robert Henderson, Actuary of the Equitable Life Assurance Society of the United States. Pages v+111. 15×23 cm. $1.25. 1915. John Wiley & Sons, Inc., New York.

Volume 15 of *Mathematical Monographs,* edited by Mansfield Merriman and Robert S. Woodward is designed to set forth in concise form the essential facts and theoretical relations with reference to the duration of human life. The first chapter gives a description of some of the mortality tables which have had a relatively important part in the history of the science of life contingencies or on its application in this country. Then the mathematical relations between the various functions connected with human mortality, and other mathematical laws which have been proposed to explain facts in this field are considered. Methods of constructing mortality tables are then taken up, and a new mortality table based on some of these methods of construction and graduation is published for the first time. Twelve mortality tables and three diagrams are included in the book. H. E. C.

A First School Calculus, by R. Wyke Bayliss, Mathematical Master at the Whitgift Grammar School, Croydon, England. Pages xii+288. 13×19 cm. $1.20. 1914. Longmans, Green & Co., New York.

There can be no doubt of the advantage of introducing the calculus by means of concrete problems. Under the old method of defining differentiation abstractly and proceeding at once to derive the rules and apply them solely in differentiating functions of one variable, the student mortality was altogether too great. Moreover, this method of instruction is the sufficient reason why so many engineers avoid all use of the calculus after they leave college.

The present volume is a capital example of the modern practice of introducing every new idea by means of a simple concrete problem as far as it is possible. The solution of a problem leads to a method of procedure or a rule, then the rule is derived by the student in response to a series of questions or suggestions. Then a list of exercises furnishes a drill in applying the rule, and this is followed by a list of concrete problems. Many suggestions and explanations are given with the answers, which fill 108 pages. These suggestions and the skillful use of the Socratic method throughout the book makes this an excellent textbook for use with young pupils and for self-instruction. H. E. C.

Practical Mathematics for Advanced Technical Students, by H. Leslie Mann, A. R. C. Sc., Lecturer in Advanced Practical Mathematics, The Woolwich Polytechnic. Pages xi+487. 15×22 cm. $2.10. 1915. Longmans, Green & Co., New York.

This textbook assumes some knowledge of elementary algebra, geometry, trigonometry, and the use of logarithms and squared paper. It is planned to cover a course of two or three years, and develops principles and processes in a systematic manner, so that the student gets a real knowledge of the underlying principles of mathematics as well as the method of applying them in the solution of practical problems.

In the first section, the parts of algebra and trigonometry necessary for successful work in the calculus are selected—partial fractions, binomial theorem, approximation, exponential and logarithmic series, the formulas of trigonometry, complex quantities, and so on. The second section gives a very practical treatment of the calculus with enough attention to the theoretical side and exercises for drill so that the student can become thoroughly familiar with the principles of the subject. The work of the third section consists of the methematics involved in the problems that must be solved by the technical student—bending moment, deflection of beams, theory of struts, and so on. Because of the well-balanced selection of theory and practice, this book should prove a very satisfactory textbook. H. E. C.

School Algebra, First Course, by H. L. Rietz and A. R. Crathorne, University of Illinois, and E. H. Taylor, Eastern Illinois State Normal School. Pages xiii+271. 13×19 cm. $1.00. 1915. Henry Holt & Company, New York.

The authors have made a special effort at presentation of principles and definitions in clear, simple style, with wordy unessentials eliminated. The laws of algebra are closely connected with the rules of arithmetic, and the close connection with arithmetic is kept in view throughout the book. The problems are new and there is an abundance of simple and carefully graded exercises. H. E. C.

Mathematics for Machinists, by R. W. Burnham, Erasmus Hall High School, Brooklyn, New York. Edited by J. M. Jameson, Girard College. Pages viii+229. 13×18 cm. $1.25. 1915. John Wiley & Sons, Inc., New York.

For a number of years the author has been an instructor in the evening machine classes in Pratt Institute. Working with men and boys who have had little mathematical training, he has written a book which

is well adapted to their needs. Beginning with fractions, his book aims to give in simple form an explanation of the calculations most frequently occurring in machine-shop work. Emphasis is placed on understanding the steps of a calculation rather than on the mechanical use of formulas. There are 175 figures and a large number of problems of a very practical type. The material and method of treatment make this an excellent text for trade and co-operative classes in day school as well as in night school. As in all books issued by the publishers of this volume, the make-up and presswork leave little to be desired. H. E. C.

Plane Geometry, by Claude I. Palmer, Associate Professor of Mathematics, Armour Institute of Technology, and Daniel P. Taylor, High School, Oak Park, Ill. Edited by George W. Myers, Professor of the Teaching of Mathematics, The School of Education, The University of Chicago. Pages v+276. 14×20 cm. 80 cents. 1915. Scott, Foresman & Co., Chicago.

The main aim of the authors has been to approach abstract reasoning by a method that is natural and comprehensible and to vitalize the subject-matter by making it interesting and useful through a wide range of practical applications. Though for the most part geometry is presented in the traditional form, at the beginning some of the fundamental theorems are shown to be true by experimental or inductive methods. Thus, the theorems on the congruency of triangles are shown to be probably true by cutting out triangles and placing one on the other, and these theorems are used as authority in formal proofs of the usual theorems dealing with parallels, triangles, and parallelograms. Later the formal proof of the theorems of congruency of triangles is given. In order to make it easier for pupils, the triangles are first called equal and later congruent.

Actual work in geometry is begun at once without a formidable array of definitions, axioms, and principles. Especial attention has been given to the selection of exercises. There are abstract exercises to give mental training exercises involving an application of arithmetic and algebra to geometry, and others to correlate geometrical facts with real life. The consideration of incommensurable numbers is introduced informally in the treatment of areas, and the discussion of the theory of limits is postponed until needed in connection with the measurement of the circle.

H. E. C.

In the June, 1915, issue of this Journal the price of the textbook "Chemistry of Common Things" published by Allyn & Bacon, Chicago, was given as $1.25. It should have been $1.50.

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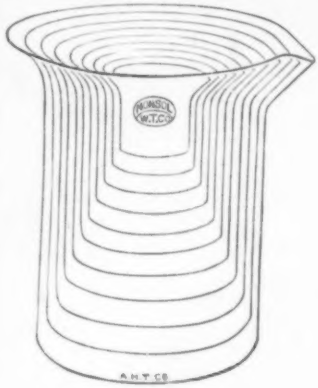

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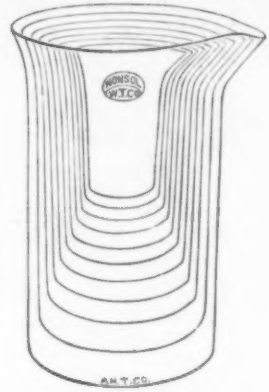

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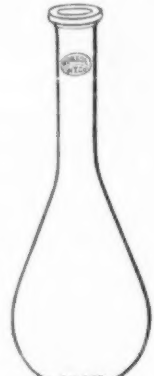

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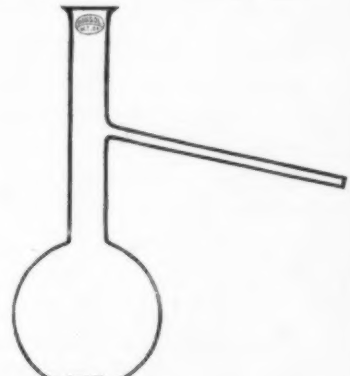

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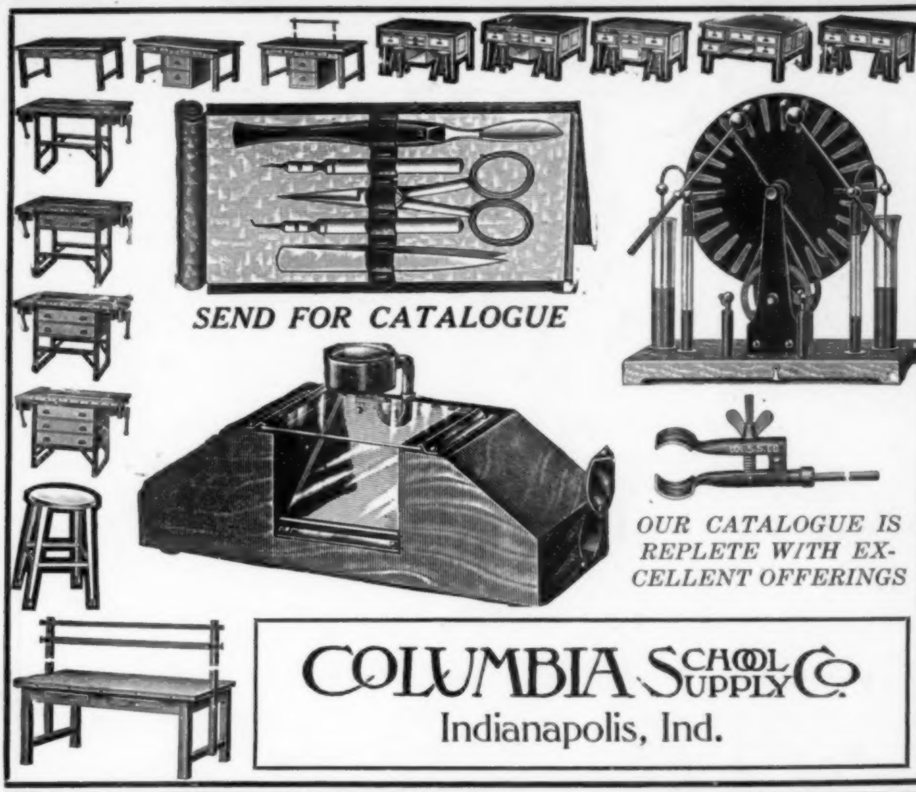
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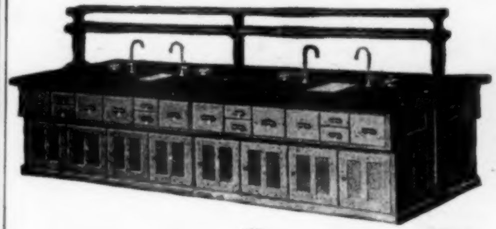

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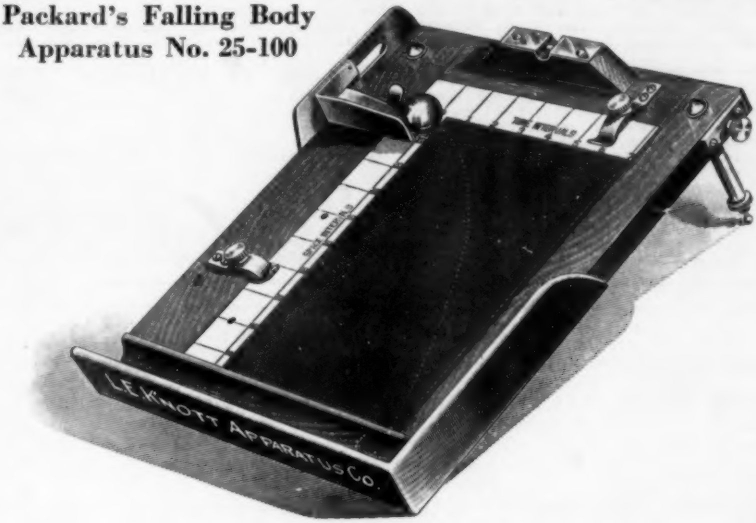

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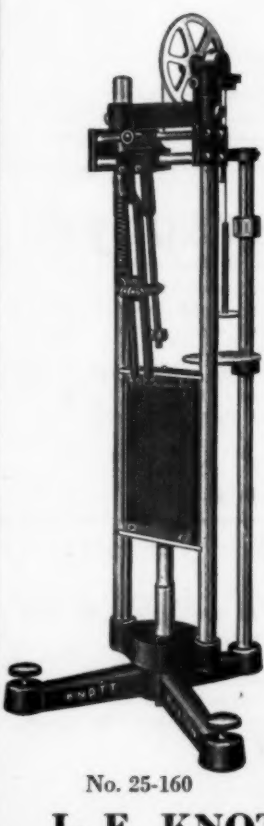

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